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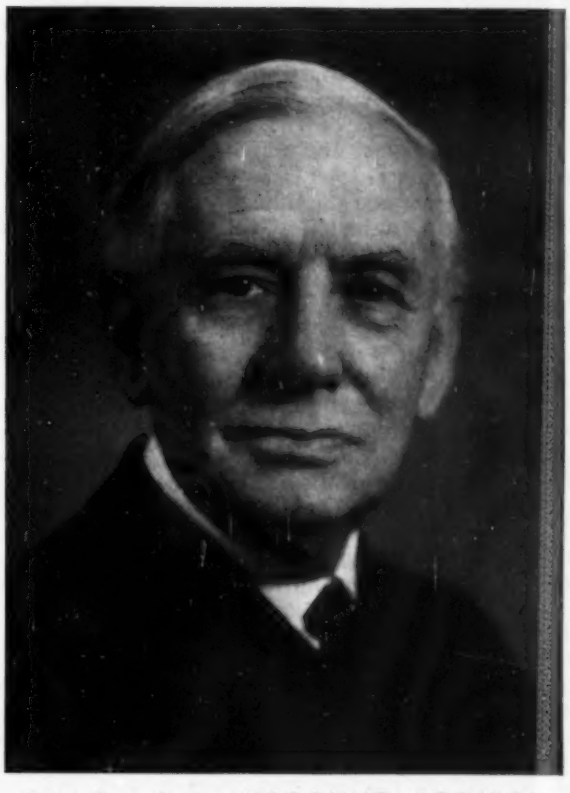
# LORD ADDISON AS ANATOMIST

By SIR ARTHUR KEITH

MOST medical men who adopt anatomy as a calling begin to establish a reputation by reporting on the anatomical accidents of the body and gradually pass on to more important subjects, but there is an exceptional few that, by the publication of a finished piece of work, pass to the front at a single bound. Of this rarer group Christopher Addison was an example. In December, 1898, when he was 29 years of age, and in the seventh year of his anatomical career, he dispatched to Alexander Macalister, F.R.S. (1844–1916), then Professor of Anatomy in the University of Cambridge, a paper entitled, " On the anatomical topography of the abdominal viscera in man, especially the gastro-intestinal canal ". It was a very long paper, running to about 35,000 words, with numerous illustrations, charts, tables of measurements, etc. The paper was sent to Macalister, I presume, in the hope that it might be ' communicated ' to the Royal Society and published in the *Transactions* of that august body. It was duly communicated and Addison read what must have been an abstract at a meeting on Dec. 8, 1898. By that time the Royal Society looked askance on all subjects relating to human anatomy; so the paper was not accepted for publication.

In the following year (1899) Addison laid his paper before the members of the Anatomical Society, and Part I appeared in the July number of the *Journal of Anatomy* of that year (vol. 33, p. 565); Part II came out in the July number of 1900 (vol. 34, p. 427), and Parts III and IV in 1901 (vol. 35, pp. 166, 277). Addison made the " Topography of the Abdominal Viscera " the subject of his Hunterian Lectures at the R.C.S. in 1901. He became a Fellow of the College by examination in 1895. His papers in the *Journal of Anatomy* were reprinted and issued in book form by Neill & Co. of Edinburgh in 1901. The book runs to 116 pages.

At the time these papers were published Addison and I were on intimate terms; he held the Chair of Anatomy in University College, Sheffield (not yet a university) and I was senior demonstrator of anatomy at the London Hospital Medical College. I have been re-reading his papers which appeared in the *Journal of Anatomy* and now realize that we, his contemporaries, underestimated the importance of the addition he had made to our subject. He did for the abdomen something of the same kind as my friend Robert W. Reid (1849–1939) had done for the head—established a base-line. The scheme which he applied to the human body was similar to that used by geographers when they map the earth. He regarded the suprasternal notch as representing the north pole of the trunk, the upper border of the pubes as its south pole, and the line joining these two points (the midline of the body) as his meridian at Greenwich. At the mid-point of his central meridian he drew a line at right angles, corresponding to the equator. This transverse plane, he found,



The Rt. Hon. VISCOUNT ADDISON OF STALLINGBOROUGH, K.G., P.C. (1869–1951)

usually crosses the ninth pair of costal cartilages, and also the pylorus of the stomach, and hence is often named the ' transpyloric plane ' or plane of Addison. Two other transverse lines were added, one midway between the equatorial line and his north pole and one between the equatorial line and his south pole. Right and left meridian vertical lines were added, these roughly corresponding to the outer border of the right and left *rectus abdominis*. Having devised this scheme he began to apply it to the human body, while still a demonstrator of anatomy at Barts

(1891–4). He found it took him about four hours to examine, measure, and map the exact position and shape of the organs contained in a single abdomen. On each body examined he made 200 measurements, besides mapping on his framework of lines, the shape of every important organ. He continued his investigation when he was appointed lecturer in Sheffield in 1894. Altogether he mapped 40 bodies, a series which involved the making of over 10,000 measurements, and 250 exact drawings or tracings. If taking pains is a mark of genius then Christopher Addison was a genius. And the gain of such a system? It provided surgeons with an exact knowledge of the range they were likely to meet with in the position and size of organs when operating on the abdomen. His scheme did more than this: it provided a means of making an exact comparison of the abdominal contents of one individual with those of another. Addison tabulated his facts most accurately, but he never sought to explain why the abdominal contents were in a high position in some people and in a low one in others. Here, as always, Addison had a practical end in view. In the introduction to his paper he wrote: "With the advance of medical and surgical science, especially with regard to operations of surgery on the abdomen, the topography of the abdominal viscera becomes of increasing importance."

Addison entered the school of St. Bartholomew's Hospital as a student on Sept. 29, 1886, he being then in his eighteenth year, for he was born on June 19, 1869. He worked for the medical degrees of the University of London and so did not reach the dissecting room until a year later—1887. There the late Sir James Berry (1860–1945) and he met for the first time. On entering the dissecting room at the beginning of term, Berry found a student sitting by the part allotted to him (an arm) perplexed and forlorn. Berry went to his help; showed him how to reflect skin and dissect out the subcutaneous nerves. That was the beginning of a lifelong friendship. Anatomy appealed to Addison; it was a subject in which there was no need for speculation, the structures dealt with were facts. When he qualified in 1891, at the age of 22, he became one of the demonstrators of anatomy in his old school, apparently resolved to make his living by teaching anatomy. That was something new for a pupil of Barts to do; hitherto its staff in the dissecting room had been recruited from pupils who hoped to be appointed to the hospital staff or were already appointed. At the time I am dealing with, the only professional anatomist in the whole of London was at University College; in all the other schools lectures in anatomy were given by surgeons or physicians. The only exception was at St. Thomas's Hospital, where my friend Dr. R. W. Reid, before being appointed to the Chair of Anatomy in Aberdeen, lectured on that subject. One of Reid's pupils, F. G. Parsons, F.R.C.S., (1864–1944) was already a demonstrator of anatomy at St. Thomas's when Addison was still a pupil at Barts. Parsons and Addison were pioneer anatomists so far as London was concerned. I joined this select company when appointed demonstrator at the London Hospital in 1895. After serving as demonstrator at Barts for three years, Addison was appointed (1894) lecturer on Anatomy in Sheffield University College. He was then in his twenty-sixth year and had again to play the part of pioneer, for his predecessors had been members of the hospital staff. He had to equip and organize a new department. After he had been in Sheffield for seven years he returned to London. The medical school of Charing Cross Hospital had resolved (1901) to appoint a whole-time anatomist and invited Addison to fill the post; to the surprise of most of us, for Charing Cross was then a minor and poor school, Addison accepted. There he laboured for the advancement of the school, becoming its Dean, for besides being an anatomist he was, as anatomists often are, an excellent man of business. In 1907 his old school (Barts) invited him to be its first full-time anatomist. There he lectured until 1913, when Parliament annexed an excellent anatomist. Hoxton constituency adjoins Barts. He canvassed it and became its representative in 1910—in the Liberal interest.

During the years following his return to London I came into intimate touch with Addison. He was then in his early 'thirties', a man of medium height, spare but wiry in build of body, capable of great endurance both in body and mind. His hair was then raven black, his complexion rather sallow, his countenance that of a student or thinker, lit up by dark lustrous eyes. He dressed soberly, unostentatiously; he appeared never to be in a hurry, always had leisure for his friends. He was a man of a friendly and loyal disposition; he covered a seriousness of purpose by a smile on his lips and a quiet sense of humour; never aggressive, always tactful, always had himself under control. He had courage and tenacity of purpose even in these early days. There was that in his manner which convinced all who came in contact with him of an honesty of purpose in word and deed. He was, beneath his friendliness, a reserved man; he was good-hearted, but not open-hearted. I cannot remember our ever discussing our inner personal affairs—affairs of religion, of morals, or even of our finances. As regards finance I suspect we were both in the same position—dependent on what we could earn. There was not anything which could be described as brilliant in his mental outfit, no invention of happy phrase or idea; never speculative; he never took a step until he had examined the ground in front of him. His understanding, when presented with a problem, never found a solution in a flash, but worked slowly and thoroughly. In short, his fellow anatomists looked upon Addison as being like themselves just an ordinary man; we never anticipated for him a high place amongst the statesmen of his period. It is easy to be wise in the light of after-events.

We must now return to the consideration of Addison as anatomist. He was an enthusiastic member of the Anatomical Society, as well he might be, for that body, now in the sixty-fifth year of its existence, was really a child of his old school—Barts. The founder of the society was Charles B. Lockwood (1856–1914) who, in the year Addison entered the dissecting-room at Barts (1887), held the post of "Demonstrator in Practical Anatomy and Operative Surgery". He had contributed a paper of merit to the *Transactions of the Royal Society* on the development of the pericardium and adjacent structures in

the human embryo and had felt the need of co-operation with those who were interested in the problems of human anatomy. He issued a circular, with the result that the society came into being and held its first meeting on May 6, 1887.* The society moved from school to school to hold its meetings. The May meeting of 1904 was held at the school of Charing Cross Hospital, where Addison was then lecturer. The chief item on the agenda was a " Discussion on Abdominal Topography ", which was opened by Addison. He said that the method he had proposed had been criticized by surgeons as unpractical, involving an unnecessary exposure of the patient's body. He claimed that the most useful surface marking he had introduced was the ' transpyloric plane ', and that this could be replaced in a very simple way, namely, by a transverse plane drawn midway between umbilicus and infrasternal notch. He went on to demonstrate that the subcostal margin, used so often as a guide to the position of abdominal viscera, was so variable as to be unreliable.

On reading the report of the discussion† for the purpose of this article I was surprised to find I took the part of the surgeons. This convinces me that I, too, had failed to grasp the true nature of Addison's scheme. It was an anatomical scheme which was designed to serve the purpose of those who wished to compare the position of the viscera of a man with that of a woman, or to compare the visceral position in men of one race with that of men of a different race. Addison maintained that his scheme served the needs of anatomists as well as of clinicians.

In the equipment with which Addison and I set out to become anatomists, we had much in common. He was son of a farmer in Lincoln, I of a farmer in Aberdeenshire; both of us kept up our interest in farming; both of us retained in our speech something of the brogue in which we grew up. Both of us were born into the atmosphere of Gladstonian liberalism. I came into the world rather more than three years before him, I in 1866, he in 1869, but these extra three years I spent in Siam and when I came to London in the autumn of 1892, to devote myself to anatomy on a moderate sum I had saved, Addison was demonstrating anatomy in Barts, so I may say we began our careers together. I took the Fellowship of the College in 1894, while waiting for a billet, he in 1895, when he had been appointed to Sheffield. As far as worldly goods were concerned we were equally poor. Both of us became Fellows of the College, not that we intended becoming surgeons, but because the possession of that diploma improved our chance of obtaining employment in the anatomical department of a London medical school. Both of us took a close interest in the affairs of the Anatomical Society. I served as its secretary from 1899 to 1901; Addison, from 1904 to 1906. We examined together for the Membership and for the Fellowship of the R.C.S. Addison excelled in that quality of mind which is known as ' common sense '; that was the quality he applied to the candidates that came before him; he seemed to retain a lively memory of how he felt when he had endured the ordeal of an examination.

Both of us postponed marriage until we reached the ' thirties '; I married in 1899, Addison in 1902, when he had returned to London and was lecturer at Charing Cross Hospital. We both made happy marriages. I married Celia Gray, daughter of an artist who died young. Addison married Isobel Gray, daughter of a shipping magnate. In these early years of the century the Addisons and Keiths saw a good deal of each other socially, for Mrs. Addison was an attractive, lovable, and capable woman, who entered into and assisted with zest all of her husband's political activities. After Addison's appointment to Barts as lecturer on anatomy in 1907, he devoted himself more and more to politics, while I applied myself more and more to the affairs of anatomy, so that our ways parted. One strange coincidence I must add: Lady Addison died in 1934 and so did Lady Keith.

After Lord Addison's death on Dec. 11, 1951, an obituary notice appeared in *The Lancet* (Dec. 22, p. 1186) in which the following passage occurs—a passage relating to his early life in Sheffield:—

> " One evening when I called to see him ", the same colleague continues, " I found him surrounded by books, but none of them had to do with science in general or anatomy in particular. They were all about history or political economy. His reply to my expression of surprise was: ' Politics is my game, not medicine '."

I have no doubt that account is true, and yet it comes to me as a revelation. I had always supposed that it was after his marriage that Addison had resolved on a career in politics. So therein I find another resemblance between Addison and myself. I became an anatomist in order that I might devote myself to extending the evidence bearing on man's evolutionary origin; Addison took up the same subject in the hope that it might lead him to St. Stephen's; and it did. He applied to politics the same methods as he used when an anatomist.

The following list of his publications in anatomy has been prepared by Mr. W. R. Le Fanu, Librarian to the Royal College of Surgeons of England.

" On the Topographical Anatomy of the Abdominal Viscera in Man, especially the Gastro-intestinal Canal " (Hunterian Lectures, Royal College of Surgeons), *J. Anat., Lond.*, 1899, **33**, 565–86; 1900, **34**, 427–50; 1901, **35**, 166–204 and 277–304.

Also *Lancet*, 1901, **1**, 759–65, 911–16, and 1059–64; and as a book:—Edinburgh: Neill & Co., 1901, 116 pages.

Discussion on same subject, *J. Anat., Lond.*, 1904, **38**, " Proceedings ", pp. xxx–xlv.

" A Discussion on the Topographical Anatomy of the Thoracic and Abdominal Viscera from a Systematic and Clinical Standpoint " (British Medical Association, Annual Scientific Meeting, Cheltenham, 1901), *Brit. med. J.*, 1901, **2**, 1065–70.

" Cervical Ribs ", *J. Anat., Lond.*, 1902, **36**, " Proceedings ", pp. lxxiv–lxxvi.

*Demonstrations of Anatomy* by G. V. Ellis, 12th edition by C. Addison. London, 1905.

On the Future of the Medical Services (Speech at Dinner of Charing Cross Hospital Medical School, Oct. 2, 1937), *Brit. med. J.*, 1937, **2**, 766.

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* See *The First Fifty Years of the Anatomical Society. A Retrospect.* By the late Prof. E. Barclay Smith, 1937.

† See *Proceedings of the Anatomical Society* for 1904, pp. 30–45, bound at the end of the *Journal of Anatomy* for that year, vol. 381.

# ABDOMINAL WOUNDS IN JUNGLE WARFARE

By JOHN A. BATY, O.B.E.

LATE LT.-COLONEL R.A.M.C.; SURGEON, THE ROYAL SALOP INFIRMARY, SHREWSBURY

A GREAT deal has been written on the subject of abdominal war wounds as encountered by different surgeons in France, Libya, Sicily, and Italy. The following paper is based on experiences gained with a Fourteenth Army Mobile Surgical Unit working on the Arakan front under totally different conditions from those pertaining in Europe or Africa. Observations are based not only on the 49 cases dealt with personally, but also on numerous other cases which were seen by the author or at which he assisted during a twelve-month period in Burma.

As in other theatres of war, the time factor is all-important and most recoveries had not received their abdominal wound more than twelve hours before operation; however, the fact that survival did occur in a few when operated on twenty-four to thirty-six hours after wounding shows that, even when received as late as this, an abdominal wound is not necessarily a hopeless surgical risk. Before going into the clinical aspect of abdominal wounds, it would be as well to describe the circumstances under which the cases were received and to indicate why it was not possible to shorten the time factor. When patrol activity provided clashes with the enemy, a wounded man might be many hours before being located in thick jungle; when found, a formidable journey lay ahead, including perhaps a 10- to 15-mile hand carriage via precipitous gradients, thick jungle, wide chaungs, and mud, with torrential downpour or blazing heat adding to the difficulties. A tribute must be paid to the bearer units for their grand work under conditions which must equal the world's worst. After the monsoon, when a more definite front became established, the mobile unit moved forward with the M.D.S. of a Field Ambulance, and at sites sometimes between our artillery and the forward troops abdominal cases were received relatively early, on an average after about five hours. Although the actual distances involved were not great, delay did occur from deliberate enemy fire to prevent collection of wounded, and on more than one occasion the man with an abdominal wound lay out in the heat all day and was only collected or managed to crawl back after sundown. It was not surprising that many patients arrived in a very bad state, either cold and soaked during the monsoon or dehydrated and pyrexial at other times. Those few cases operated on within an hour or so were most often wounded in or about the immediate neighbourhood of the M.D.S. The time before operation cannot usefully be reduced under, say, five hours, for once the case has been dealt with, it is imperative for the patient to be at a site where he can be held for at least seven to ten days before evacuating. Thus there is a definite limit to the proximity to the enemy at which mobile surgical units should carry out major abdominal surgery: it is hardly worth while 'doing an abdomen' unless the patient can be retained and nursed over the critical period under conditions of relative safety. Abdominal cases, which on account of the military situation had to be evacuated immediately after operation, either died or only survived after a desperate struggle.

*Gunner C.* (March 6, 1944) received two hours after sustaining a machine-gun bullet wound of the right abdomen, the missile having first passed through his right forearm and splintered his own rifle butt. Lacerated jejunum prolapsed through the abdominal defect. After resuscitation, exploration through a right lower paramedian incision, prolapsed bowel reduced. Found necessary to resect some 1½ ft. of jejunum. In addition, perforating wounds of the transverse colon required repair and a bleeding omentum had to be ligatured. Cæcostomy performed after closure of the abdomen over a 'Vaseline' lint roll. The bullet was not located, but pieces of wood were removed from the peritoneum during the routine examination. The compound fracture of the forearm was excised and enclosed in a split plaster. At the end of operation pulse was 130 and B.P. 120/80.

Enemy action made it necessary to evacuate the patient within four hours of the termination of the operation. An intravenous drip was maintained during a slow ambulance journey. In spite of a specialist transfusion officer's attendance during evacuation, the patient's condition was critical on arrival at C.C.S. after eight hours' bumping. Death occurred within twenty-four hours.

*Corporal R.* (March 4) reached the surgical unit eleven hours after sustaining a perforating bullet wound of the abdomen. Entry wound lay above and to the left of the umbilicus, whilst the exit was over the eighth right costal cartilage. Operation carried out after giving a single pint of plasma, and, on opening, the peritoneum contained quantities of blood, bile, and gas. B.P. was 140/90 and pulse-rate 100.

The lesions were:—

- Double jejunal perforation 6 in. below flexure—closed with purse-string sutures.
- Perforation anterior wall of pyloric antrum—sutured.
- Embedded metallic flakes in posterior wall of stomach—removed and overstitched.
- Double perforation of second part of duodenum—mobilized and double-layer closure.
- Laceration of gall-bladder (Hartmann's pouch)—sutured.
- Radiating liver fissure (not bleeding)—untouched.
- Hæmorrhagic effusion between the layers of lesser omentum and retroperitoneally—undisturbed.

The pleura had escaped damage. Abdominal wound drawn together and tension sutures tied over a 'Vaseline' lint roll. In addition to pelvic drainage, a stab drain was in position from the region of the gall-bladder to the right flank. In this case the elevated blood-pressure was probably due to hæmorrhagic irritation of the splanchnics.

On the third post-operative day, before flatus was passed, it was necessary to arrange a hurried evacuation. No dressing was carried out and the patient, accompanied by the transfusion officer, made the rough journey back to the C.C.S. The loin wound was draining bile, suprapubic drainage had occurred, the duodenal tube was in position, and the intravenous drip was being maintained. At the C.C.S. it looked as if this patient, too, would go under as the result of the journey. However after skilful nursing over several critical days a turn for the better took place. Thereafter good progress was made and in three weeks evacuation was possible, by which time bile drainage had ceased. Further after-care was provided at a Forward General Hospital and the patient improved

so markedly that he could be evacuated to Base as a sitting case. Apparently the wound healed without secondary suture.

## DIAGNOSIS

Many abdominal and thoraco-abdominal cases leave little doubt as to whether the abdomen needs opening. Even minute wounds over the abdomen should be carefully excised and the track explored: not infrequently it is found that an insignificant puncture leads down to a perforated viscus. A few cases were encountered in which intraperitoneal lesions apparently had occurred with intact parietal peritoneum.

Dogra (Nov. 3, 1943). The patient reached the surgical unit twenty-six hours after sustaining a mortar wound below and to the left of the umbilicus. He had lain out for twelve hours under Jap positions and managed to crawl in, himself. The pulse was 90 and B.P. 100/60. There was no pyrexia. General abdominal rigidity was present and rectal examination revealed a tender pelvic peritoneum. After 2 pints of plasma, the skin wound was excised and the track followed through the abdominal wall towards the left, this exploration producing a transverse incision. A small metallic fragment was located lying over intact peritoneum. In view of the preoperative signs, the peritoneum was opened to expose left-sided peritonitis fed by three leaking jejunal perforations. These were closed within purse-string sutures and gross peritoneal contamination mopped out. Having made provision for drainage of the abdominal wall and pelvis, the abdomen was sutured in layers.

After a stormy post-operative period, during which time duodenal tube and intravenous drip were employed, the patient passed flatus on the fifth day. It was necessary to remove all the sutures from the abdominal wound to allow free discharge of pus. Thereafter good progress was made, allowing evacuation fourteen days after operation.

Large shell wounds causing loss of substance in the abdominal muscles can cause gross intraperitoneal lesions without opening the peritoneum, the damage being produced by the wave which radiates through the viscera when such terrific energy is liberated in their neighbourhood.

*Gunner T.* (Feb. 7, 1944), a couple of hours prior to arrival at the M.D.S., had received a shell wound of the left abdomen: muscle had been carried away, exposing an area of undamaged peritoneum some 6 by 5 in. After plasma the patient improved to allow operation. Wound excision was followed by opening of the peritoneum. Removal of a grossly lacerated enlarged spleen was carried out, a tear of the pancreatic tail was sutured, and the bleeding points on a vertical jejunal mesenteric split were caught and the defect closed without impairment of blood-supply. Flank drainage was employed, and, after peritoneal closure, tension sutures were tied over a 'Vaseline' roll. Two pints of blood were given during operation, at the end of which the patient's condition was fair.

An intravenous drip was maintained in the afternoon following operation, during which time the temperature rose to 105°. Death occurred ten hours later in spite of intravenous quinine. There had been no recurrence of intraperitoneal hæmorrhage.

In the absence of X rays, the small penetrations in the region of the diaphragm can present a difficult diagnostic problem. If the track on the right side is followed via pleura and diaphragm, the liver penetration is seen and a gentle probe of the track may enable one to be satisfied that the fragment has lodged in the liver. Even where the fragment has been arrested in the liver, the small amount of blood which trickles down from the diaphragmatic surface gives rise to right-sided abdominal pain and rigidity. In hospital it would be possible to keep a doubtful case under observation for a number of hours. In the field, these doubtful cases were subjected to a small upper right laparotomy; such patients were usually not desperately ill and were none the worse for a 'look see' policy. On occasions, the findings at laparotomy revealed bowel perforations, amply justifying exploration.

X rays when available were an undoubted help in reaching a decision regarding the peridiaphragmatic wounds. For example, a patient had a small mortar fragment penetration through the eighth left intercostal space in the mid-axillary line; X-ray examination showed the fragment lying just above the diaphragm. A straight line between point of entry and position of fragment passed through the stomach fundus, but on deep inspiration the line lay entirely above the diaphragm. The patient on hearing the approach of the missile, in addition to getting prone, would have automatically taken a deep breath and held it in anticipation of the explosion, thus sustaining a purely thoracic wound. The patient was kept under observation and could be evacuated in a few days quite free from symptoms.

Sometimes the well-known referred abdominal rigidity from chest wounds can be very misleading. A patient can have intense abdominal pain and general rigidity even with a purely thoracic lesion.

*Hav. S.* (Feb. 18, 1944) was seen twenty-one hours after sustaining a grenade wound. The entry was immediately to the left of the body of the sternum at the level of the fourth cartilage, with exit in the anterior axillary line at the same level. The fragment had finally been arrested by the left humeral shaft (unfractured). The patient was in poor condition and considerably distressed by the open blowing pneumothorax at his exit wound, the occlusive dressing having slipped. Even with his critical chest condition, his main complaint was intense abdominal pain; general rigidity was present, especially on the left. Using local anæsthesia it was not possible to do more than effect an air-tight closure of the chest around a Malecot catheter. Following closed drainage, the general condition steadily improved, but it was forty-eight hours before the abdominal pain and rigidity had disappeared. The patient was evacuated a week later in fair condition. In this case the tract of the missile alone convinced one that the wound could not be a thoraco-abdominal.

As a contrast, a case to be described more fully later had a right open pneumothorax with no abdominal symptoms or signs. At thoracotomy, a bullet hole in the right diaphragm was seen and subsequent laparotomy revealed duodenal laceration.

Before leaving the subject of diagnosis, it is as well to mention that routine catheterization should be carried out immediately before operation. Hæmaturia may disclose an unsuspected injury to the urinary track, and in any case an empty bladder is necessary before laparotomy.

## RESUSCITATION

Many of the more extensively wounded were moribund when received. Some had been delayed at the A.D.S. for the administration of plasma; these

patients were just as 'flat out' on arrival at the M.D.S. and were a more difficult problem, not responding as readily to a second resuscitation as the case which received one resuscitation only and that immediately before, during, and after operation. Even in the desperately ill abdominally wounded it appears to be unwise to delay evacuation in order to resuscitate. Any improvement in condition is transitory and does not justify the delay. Hypodermic injections of morphine ½ gr. often failed to give ease, and such deposits of morphine apparently only reached the circulation when the blood-pressure rose with the administration of plasma, and on more than one occasion increased the anæsthetic hazard. For the man with a belly wound, morphine ¼ gr. given intravenously produces an immediate effect, and a further ⅛ gr. can be added hypodermically for the journey. On arrival one or more pints of plasma were given at once, to be followed by whole blood (when available) immediately preceding laparotomy. The opportune time for operation was judged by observation of the patient's condition, blood-pressure and pulse readings being made at frequent intervals. Those patients whose systolic pressure could not be brought over 90 mm. and whose diastolic was unrecordable rarely survived at operation; gross multiple intra-abdominal lesions were usually found.

*Private M.*, admitted at 1200 hours on Oct. 28, 1943, ten hours after sustaining an abdominal bullet wound, showed entry wound over the right costal margin, no exit, but considerable swelling with surgical emphysema in the right loin. On arrival pulse was 140 and blood-pressure 85/40. Bowel action produced quantities of dark blood-clot. A catheter specimen showed almost pure blood. After 2 pints of plasma the pulse-rate had risen to 160 and the blood-pressure fallen to 70/40. Exploration by right paramedian incision with transverse extension revealed a gross laceration of the transverse colon and mesocolon requiring resection and exteriorization of the ends. The duodenum was mobilized to expose and repair a peritoneal entry and retroperitoneal exit. The right renal pedicle was intact, but bleeding from a tear of the lower pole was controlled by suture. There was a considerable area of contamination in the loin, fæces and gas having been driven into the retroperitoneal tissues.

Whole blood could not be obtained until after the operation, but it failed to prevent a fatal termination. The patient did not survive long enough to die from colon toxæmia.

Although it is not always possible, one should try to open the abdomen on a rising blood-pressure and falling pulse rather than delay until the pressure has reached its peak and is beginning to fall again. A couple of pints of whole blood will sometimes enable the favourable state to be reached. There is no doubt as to the value of whole blood and such can be most advantageously employed at a time when transfusion is to be shortly followed by intra-abdominal ligature of the bleeding vessels; thereafter further blood will produce a steady improvement in the patient's condition provided there is no gross fæcal contamination of muscle and the total lesions do not add up to a 'lethal dose of shock'. Routine of blood-pressure and pulse charts were not made out for the earlier abdominal operations, but the value of such written records was realized, and in most of the later cases a chart was kept by the anæsthetist before and during operation. The ideal may be for the abdomen to be closed within the hour, but unfortunately intra-abdominal wounds are frequently multiple and it is useless to close the abdomen unless and until all lesions have been dealt with. However, the record of the blood-pressure and pulse every ten to fifteen minutes will give clear indication as to how the patient is standing up to the operation, and it should afford a guide as to what measures can be safely adopted. If the individual surgeon gets some idea as to how long he will take to do, say, a resection and anastomosis, he can judge how much longer the abdomen will have to be kept open, and if all is not well may have to substitute for the resection some procedure which deals with the lesions more conservatively and speedily. In the case of thoraco-abdominal cases, after a formidable shock-producing thoracotomy, it has been found of value to pause before carrying out laparotomy. During the pause, subcostal block and local infiltration can be carried out and more plasma or blood given. After some thirty minutes conditions are sufficiently well restored to allow laparotomy with greater safety.

*P.*, on Aug. 7, 1943, was admitted to the M.D.S. within an hour of being wounded by aircraft machine-gun fire. The patient lay perfectly still, hardly breathing through his open right pneumothorax. Other wounded from the same action were dealt with first, a temporary occlusive dressing having been applied to the patient's chest wound. Several hours later, after resuscitation had brought the blood-pressure to 94/68 and the pulse below 100, operation was carried out under local intercostal block. The large wound of entry was excised and portions of shattered 3rd, 4th, and 5th ribs removed. At thoracotomy the lung was drawn out and a double tear (non-bleeding) of the lower lobe sutured. Inspection of the right dome of the diaphragm revealed a circular bullet hole. A single suture closed the diaphragm, and utilizing the pectoralis major, the thoracic wound was approximated with difficulty, leaving a superficial corrugated drain in position. Removal of a portion of the 9th rib posteriorly allowed insertion of a Malecot catheter. The systolic pressure had dropped to 84 mm., and diastolic became barely recordable; the pulse, however, had not risen above 110. At this stage a pause of twenty minutes was made, during which time a pint of plasma was given and subcostal block carried out. The blood-pressure rose to 92/62 and the pulse came down to 100. On opening the abdomen, a dry exit from the lower surface of the liver was seen, together with a split along the second part of the duodenum, the contents of which were escaping. The duodenum was mobilized and a double-layer repair carried out. The bullet had apparently passed into the posterior abdominal muscles and no search was made for it. The abdomen was closed with stab drainage of the peritoneum via the right flank and suprapubically. At the end of the operation pulse was 110 and blood-pressure 92/60.

Post-operatively, whole blood, intravenous drips, duodenal tube, and closed negative-pressure chest drainage eventually saw the patient over the critical period. The abdominal wound became septic, requiring the removal of stitches. It was possible to retain the patient for a month, by which time wounds were healed and the lung had expanded. He was allowed up before being evacuated and later reports confirm that recovery was complete.

The best working conditions for abdominal surgery pertained when a Transfusion Unit was

attached. Such a unit laid in a good stock of blood in their refrigerator before a battle. The patient who at first sight seemed unlikely to be in a condition for operation, within fifty or sixty minutes was revived from a moribund state to one which permitted laparotomy, blood having been delivered into his circulation at speed under positive pressure for the first pint at least.

## TECHNIQUE

**Anæsthesia.**—Usually induction was by pentothal, followed by endotracheal nitrous oxide, oxygen, and ether. After the general abdominal exploration, the ether was cut off, to be restarted for any deeply seated procedure and for closure. I was fortunate in having in Major George Quayle a thoroughly efficient, imperturbable anæsthetist, of utmost importance when dealing with severe abdominal wounds. In the thoraco-abdominal cases, novocain costal block was used for the thoracic part of the operation, and gas, ether, and oxygen for the laparotomy.

**Approach.**—The original abdominal wound may be conveniently situated to allow its excision in the laparotomy incision, and on occasion excision with transverse prolongation has allowed adequate approach to the underlying lesions. When possible a paramedian incision was used, and in no case was it considered necessary to extend the incision from xiphisternum to pubis. The positions of the entry and exit wounds, together with the physical signs, frequently gave a clue as to whether upper or lower abdomen demanded first attention; the supra- or infra-umbilical approach was accordingly made, perhaps extending an inch beyond the umbilicus. If, on opening the abdomen, the preliminary inspection revealed that laterally situated organs might be involved, a transverse incision was added to the paramedian, rectus muscle being divided. This transverse rectus division, coupled with adequate mobilization of the viscus, gave good exposure.

It was not uncommon to see omentum protruding through the wound; a pull down, with transfixion, ligation, and removal preceded wound excision. Prolapsed bowel was invariably found to be lacerated, and larger defects were roughly closed before the loop was drawn back into the abdomen and there the whole situation reviewed.

In thoraco-abdominal cases, when the chest wound is large or open, it is advisable to attend to the thorax first; inspection will reveal the diaphragmatic perforation or laceration, which can be more easily dealt with from above before completing air-tight closure of the chest and proceeding with laparotomy. Through the diaphragmatic opening only a limited examination of the abdominal contents is possible, and, if doubt exists, the only alternative is closure of the chest and an anterior abdominal approach.

*Pilot Officer D.*, on Feb. 23, 1944, crash-landed after having sustained a thoraco-abdominal-arm wound from ground rifle fire. He was brought forward to the surgical unit, which he reached three hours later. The entry wound over the seventh left cartilage lateral to the nipple line was plugged by prolapsed omentum. The freely bleeding exit wound was over the eighth right space medial to the nipple line. The bullet had lodged in the right forearm without bone, vascular, or nerve lesion.

Operation was carried out under intercostal and subcostal novocain block. After ligating and removing the prolapsed omentum, the entry wound was excised and portions of shattered costal cartilage removed. The left lung was undamaged. A tear of the left diaphragm anteriorly had extended into the fibrous portion, exposing extrapericardial fat. The diaphragmatic opening was enlarged to allow examination of undamaged spleen and stomach. After repairing a deep bleeding laceration of the left lobe of the liver, the diaphragm was drawn forward to be sutured to the parietal pleura interiorly and laterally. The chest having been closed, deep sutures drew together the remainder of the wound and tension sutures were tied over a 'Vaseline' roll. Sulphanilamide 'Vaseline' dressings only were applied to the exit and arm wounds and the transfusion of two pints of whole blood was given.

Immediate post-operative course was uneventful and bowel action was obtained on the fifth day. Then a dressing revealed wounds free from infection, and clinically no hæmothorax could be detected. The patient was evacuated by air seven days after being wounded, and later reports were of the development of a left empyema requiring drainage. Some five months later the patient was seen in good health, about to depart on leave before resuming flying duties.

Bitter experience with small thoraco-abdominal mortar wounds leads one to the conclusion that a small thoracic entry wound is best just cleaned and dressed and the case tackled initially from the abdominal aspect.

**Intra-abdominal Bowel Lesions.**—On opening, the first object is to locate and control any source of profuse hæmorrhage; bleeding is liable to show increased activity as the result of transfusion, laparotomy, and exploration. A common source of hæmorrhage is the jejunum, a few small perforations of which can soon result in a peritoneal cavity full of blood. Quite frequently the semi-dilated damaged portion of small bowel presented on opening the abdomen; temporary occlusion was effected whilst a rapid but systematic examination of the whole bowel was carried out up and down from this point. Sometimes during this examination, the foreign bodies were found lying free; if foreign bodies were not located as the bowel was examined, no special search was made for them.

It is as well to get a complete picture of the total damage before starting repair. Multiple repairs can be more time-consuming than a resection of the damaged loop; in addition, post-operatively, the œdema which is associated with a large series of repairs is liable to cause more interference with the re-establishment of peristalsis than a single anastomosis. It should be borne in mind that the loop of bowel with an easily closed perforation on the free margin has certainly another hole in the region of the mesenteric attachment. The location of this defect may not be obvious but it must be found. A small hæmatoma at the mesenteric attachment needs opening up and the portion of bowel between the mesenteric leaves should be exposed; a prolapse of mucosa indicates the site of perforation. The opposing margins of such a defect should be caught with fine forceps and, whilst held to convert the opening into a transverse slit, a short continuous invaginating suture inserted adequately to close the defect. The mesenteric peritoneum is then approximated, tying round adjacent forceps applied to the

edges. Where there was interference with the blood-supply or where multiple perforations were close together, it was the custom to carry out resection. After division and ligation of the mesentery the crushed bowel ends were closed by a single catgut ligature, which in turn was buried within a purse-string of fine linen thread. Lateral anastomosis by double layer was carried out, the stoma being at least 1½ in. in length and no less than 1 in. away from the invaginated stumps. No clamps were used in the performance of small-bowel anastomosis.

*Major A.*, on Dec. 31, 1943, was admitted twelve hours after receiving mortar wounds of left shoulder, right forearm, and abdomen. The entry wound of the latter was in the midline 2 in. above the pubis, a small knuckle of omentum prolapsing. The general condition was fair, with pulse 120 and blood-pressure 108/70. Prior to operation 2 pints of plasma were given and catheterization produced clear urine.

A subumbilical midline approach was made, encircling the entry wound and excising prolapsed omentum. The peritoneal cavity was full of blood. During routine examination, the metallic fragment lying free was removed. Four upper jejunal perforations were present, one being situated between the leaves of the mesentery. Closure was effected by purse-string and transverse suture respectively. In the lower jejunum at least a dozen lacerations and perforations were located. Individual repair might have been possible, but since the lesions were included in 1½ ft. of bowel, resection and lateral anastomosis was performed. The abdominal wound, after peritoneal closure, was drawn together with tension sutures over a 'Vaseline' roll and pelvic drainage established.

Post-operatively, intravenous drip and duodenal tube were maintained until the fourth day, when flatus was passed. A relapse necessitated the re-insertion of tube and drip, but twenty-four hours later a soap and water enema gave a copious result. Thereafter the bowels moved regularly and apart from a local left pleurisy after two weeks, progress was maintained. The abdominal wound remained clean and tension sutures were removed on the twelfth day, corset strapping being substituted. The patient was evacuated in good condition twenty-one days after operation and later was awarded the D.S.O.

The so-called fixed parts of the bowel can be readily rendered mobile to allow proper inspection, and as a preliminary to whatever procedure may be necessary. Where a lesion of the right or left colon is present, in addition to the making of a transverse extension of approach the lateral peritoneal reflection should be divided and the bowel freed medially. The upper left colon and splenic flexure come readily into view when such a procedure is combined with division of the phrenico-colic ligament. Similarly, mobilization of the second part of duodenum facilitates inspection and repair; division of the posterior leaf of the lieno-renal ligament allows early control of the vascular pedicle before splenectomy.

*Private T.* (Jan. 26, 1944), was received seven hours after the entry of a bullet through the left flank. Exposure was by a long paramedian incision which revealed damage to both large and small bowel. Two jejunal tears, with extensions into the mesenteric vessels, required resection of 6 in. of jejunum at a point 3 in. below the duodeno-jejunal flexure. Continuity was re-established by lateral anastomosis. Two lacerations of the ascending colon and a transverse colon laceration just distal to the hepatic flexure were present. The cæcum had a subserous hæmatoma over its free portion and an extensive tense retroperitoneal hæmatoma had obviously arisen from the right colic vessels. The terminal 6 in. of ileum, cæcum, ascending colon, and transverse colon to its middle were first mobilized and, in view of the patient's good condition during operation, resected, the ends being invaginated before carrying out a lateral anastomosis between ileum and transverse colon. Pelvic stab drainage having been instituted, the abdominal incision was approximated over a 'Vaseline' roll.

The patient had a remarkably uneventful post-operative course, flatus and fæces being passed with the aid of an enema on the fourth day. A pint of whole blood was given the day after operation and a further pint on the eighth day. The usual procedure with drip and indwelling duodenal tube was maintained. General condition steadily improved and on Feb. 6, 1944, the palpable bullet was removed under local anæsthesia from below the right iliac crest. Twelve days after operation, evacuation to the C.C.S. took place, the man having daily bowel action, a steady increase in weight, and clean wounds. Air evacuation had been arranged from the C.C.S., but on the day the patients arrived there, the C.C.S. itself had to withdraw hastily on account of the Jap offensive and subsequent progress of the case is not known.

The procedures adopted for the actual lesion will be determined by the state of the large-bowel blood-supply, the extent of the damage, and, by no means least, the patient's condition. Retroperitoneal hæmatomata may be associated with damage to the main colonic blood-supply and require a resection and anastomosis or exteriorization of bowel ends as a colostomy. Where both entry and exit wounds are intraperitoneal, double layer suture should not be difficult, and on occasions several neighbouring holes may be joined into a single defect which can be sutured transversely. The danger of a post-operative necrosis at the suture line is obviated by the performance of a cæcostomy which relieves intraluminal tension and prevents a blow-out at the site of repair.

Large bowel wounds produced by high-velocity missiles passing from before backwards are particularly lethal. Such wounds frequently are associated with gross contamination of the retroperitoneal structures, fæcal material being firmly driven into the psoas or iliacus over a wide extent and through the whole thickness of the muscle to appear at the exit wound. All cases of this type which were seen or dealt with invariably died in spite of free drainage, local sulphanilamide insufflation, and intravenous sulphanilamide. The pulse-rate would increase uninfluenced by blood transfusion, restlessness persist after morphine, and the general condition rapidly deteriorate, with increasing abdominal distension, although a duodenal tube was in position. Death occurred some forty-eight hours after operation, the clinical features being those of an intense toxæmia. Sir John Fraser's 'colon septicæmia' has not been favourably influenced by sulphanilamide, as was originally hoped. This condition presents features of an intense toxæmia, and death is due to a flooding of the circulation with potent bowel toxins which are literally being absorbed from an intramuscular injection of fæces. The excision of all this fæcal tattooed muscle has been suggested (J. B.). Such would be a formidable procedure, and so far no opportunity has arisen for a trial. Nevertheless, the retroperitoneal muscle is a toxin reservoir and its removal would be worth attempting when certain death is the only alternative.

In odd cases, where retrocolic contamination had been of a lesser degree, the patient was able to cope with the initial toxæmia and, later, drainage of pus occurred. The penetration of large bowel from the posterior aspect via clean muscle is less liable to result in the injection of fæces. Recovery can follow drainage of the retrocolic hæmatoma or abscess, in spite of the fact that it may not be possible to locate the wound or effect extraperitoneal repair of the bowel wall.

Rectal wounds are notoriously dangerous in producing a gross intramuscular injection of fæces, and are liable to be followed by colonic toxæmia if excision of such muscle is inadequate. The immediate performance of a colostomy, properly mobilized to ensure that the loop is tension-free, is essential if a buttock wound excision is to be of any avail.

*N. K.* (March 11, 1944), was admitted six hours after sustaining multiple grenade wounds—chest, buttock, and left flank. Only the latter penetrated, and through the wound a loop of torn pelvic colon protruded. The flank entry wound was excised and the incision extended transversely around the abdomen. The peritoneum contained fæces, blood, and vegetable matter, and there was tattooing of the whole left iliacus muscle with fæces which extended down to a comminuted fracture of the left ilium.

Peritoneal toilet was carried out and the damaged colon ends were exteriorized. Suprapubic drain of the pelvis and double corrugated drain extraperitoneally of the left iliac fossa were placed in position, sulphanilamide powder having been freely insufflated. The wound was approximated over a 'Vaseline' lint roll.

In spite of a pint of whole blood followed by 3 pints of glucose-saline-sulphanilamide, the pulse-rate steadily rose beyond 140.

A duodenal tube was in position, but abdominal distension soon became evident. The patient was cold, clammy, and restless; death occurred within thirty-six hours of operation.

**Closure of the Abdomen.**—Earlier in the campaign it was the custom to close the abdomen in layers, having made separate stab drainage of the peritoneum. At operation an effort was made to prevent gross incisional contamination and, before suture, sulphanilamide powder was freely insufflated. After the peritoneal closure, the various layers were united with interrupted sutures and what appeared to be adequate drainage of the rectus sheath provided by corrugated rubber or 'Vaseline' lint. The majority of these wounds developed a varying degree of sepsis, requiring removal of sutures to allow escape of pus. It was decided that in future abdominal incisions would not be closed and the adoption of this practice obviated the worry and complication of abdominal wound infection. The suture of peritoneum with posterior sheath was carried out as before. Four or five silkworm gut tension sutures were then inserted through all layers down to but excluding the posterior sheath. The tension sutures were tied over a substantial roll of 'Vaseline' lint. No further closure was attempted and thereafter no abdominal wound infection was seen. In due course, after evacuation to a Base Hospital, closure by secondary suture should not have been a very difficult or formidable procedure.

Abdominal bowel wounds are associated with gross intraperitoneal contamination; even if the abdomen could be kept open long enough for a complete toilet, the escape of quantities of stained fluid from the tube during the first twenty-four hours following operation, suggests that an avenue of escape is as well provided. A split rubber-tube drainage of the pelvic peritoneum was carried out suprapubically through a separate stab, the tube being shortened after twenty-four hours and discontinued by the third day. I have seen nothing but good from such drainage—in fact, in one case where no drainage was employed for a single bowel perforation, a most resistant ileus was only overcome with considerable difficulty.

In civil surgery there may be the tendency to over-swing the pendulum as regards the non-drainage of perforations. No doubt should arise in dealing with bowel wounds in warfare; they all require pelvic drainage.

## POST-OPERATIVE CARE

Unfortunately in a number of cases, the military situation necessitated evacuation in the early post-operative period and, as already mentioned, such patients rarely survived. At other times it was possible to nurse the patients over and beyond the critical period. The Fowler position was adopted when the effects of the anæsthetic had passed and an intravenous glucose-saline drip was carried on after the patient returned to the 'ward'. At this stage an odd pint or two of whole blood would be particularly helpful. When post-operative pain and restlessness began to appear, morphine ¼ gr. was given intravenously, and thereafter morphine ¼ gr. hypodermically when required and at least each evening until bowel action was secured.

The duodenal tube was introduced via the nose as a routine procedure during the first twenty-four hours to anticipate ileitic restlessness, tachycardia, distension, and general worsening in condition which precedes actual regurgitation. At first it was no mean task to prevent a patient from pulling out his tube or drip alternatively; however, he would soon realize that the abdominal well-being far outweighed the nasopharyngeal annoyance of the tube. The indwelling tube was carried over the side of the bed into a quart bottle on the ground and drainage initiated by syringe suction. After free evacuation of stomach contents was established by this means, the patient was encouraged to take water freely by mouth.

The tube was maintained undisturbed until flatus was passed, either spontaneously or with the aid of an enema. The time for removal varied considerably and on more than one occasion a relapse of ileus necessitated reinsertion of the tube. Those cases which survived required this drainage for four to six days before it could be discontinued. Whilst the tube was in position, a continuous intravenous drip was continued, the amount of fluid given by this route being stepped up when sweating was profuse on account of the heat. In most cases Dagenan soluble was added, initially 1 g. to every pint and later 1 g. to alternate bottles, varying according to the individual case and attempting to get in a total of 30 g. within the first four to five days. At times a malarial flare-up would require the addition of quinine to the drip.

## WORKING CONDITIONS

During and for a time after the monsoon, the surgical unit worked in specially erected bashes. Lighting was by a pair of carrier headlamps fed from 6-volt accumulators. One of the headlamps was suspended on bamboo runners and could be moved to head or foot of table as required. At the beginning of 1944, forward surgery was carried out in an EPIP tent, which invariably was dug into a hillside to give protection, increased head room, and a cut-out shelf on one side; 180-lb. tents were added as sterilizing and resuscitation rooms. Particular attention had to be directed towards rendering the theatre dust- and insect-proof by day and both insect- and light-proof after sundown.

The post-operative nursing difficulties will be appreciated from the fact that only Sepoys without special training were available. However, these nursing Sepoys soon became quite expert, and on one occasion were coping with 5 post-operative abdomens, all with drips and duodenal tubes, in the same ward at the same time. The post-operative wards were a series of 180-lb. tents dug into bush-covered hillside and at night a single shaded hurricane lamp and hand torches were the only lights. After the operation, the patients were liable to have their nights disturbed by close fire, of various types, and during the day heat and flies made afternoons particularly trying.

## RESULTS

Of the 49 cases dealt with, some 13 had soft-tissue and bone lesions in addition to the abdominal wound. A further 12 in this series were thoraco-abdominal cases.

Death occurred in 19 cases, the remainder being evacuated at varying times after operation. The majority of those evacuated were well beyond the critical period, and, of these, inquiry has disclosed 1 further death. A few of the British patients have written several months after their operation and given progress reports. From the information available, it is not possible to give an accurate recovery rate.

Most of the deaths occurred in the immediate post-operative period; some of these patients had extensive multiple intra-abdominal or thoraco-abdominal wounds. The various lesions would be dealt with and plasma or blood given in adequate quantities to replace the amounts lost; nevertheless, death was not long delayed, particularly in those patients who had been many hours in an exsanguinated state; it would appear that a 'lethal dose of shock' is a very real condition. Deaths within the first few days were amongst those patients with gross fæcal contamination of muscle, producing colon toxæmia. Of later deaths, purulent pneumonia was responsible for 2 cases and uræmia for 1 case.

## SUMMARY

1. A compromise should be found, so that efforts to reduce the time factor do not necessitate major abdominal surgery being carried out at a site where post-operative nursing is nil and where it is not practical to hold beyond the critical period.

2. Readily available whole blood may mean all the difference between success and failure.

3. Pulse and blood-pressure charts before and during operation are a valuable guide.

4. An intra-abdominal lesion may underlie an intact peritoneum.

5. A transverse extension added to the vertical incision gives adequate exposure. So-called fixed viscera can readily be mobilized.

6. A cæcostomy for a colon repair is just as important as a colostomy for a rectal wound.

7. Multiple bowel lesions may be more quickly and effectively dealt with by resection and lateral anastomosis.

8. Abdominal incisions should not be closed. Pelvic drainage is necessary in all abdominal war wounds.

9. The duodenal tube and intravenous drip post-operatively are life-saving.

10. Gross fæcal contamination of muscle is particularly liable to be followed by a fatal colon toxæmia which is uninfluenced by sulphanilamide.

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# THE MECHANISM, REDUCTION TECHNIQUE, AND RESULTS IN FRACTURES OF THE OS CALCIS*

By The Late PETER ESSEX-LOPRESTI
SURGEON, BIRMINGHAM ACCIDENT HOSPITAL

It has long been generally accepted that the results of fractures of the os calcis are bad, and that recovery is slow and incomplete. Conn in 1926 wrote that they are " serious and disabling injuries in which the end-results continue to be incredibly bad ", and in 1935 he added that all the 26 old cases he examined had " pronation of the heels, planus of the long arches, and valgus of the forefoot, with persistent disabling pain ". Mercer (1944) states that " fractures of the calcaneus are among the most disabling of all injuries ", but adds that " as in joint injuries elsewhere, improvement is slow, and it may be three or four years before recovery reaches its maximum ". Simon and Stultz (1930), agreeing with all this, attribute it to " the fact that contrary to the general principles of the treatment of fractures, reduction in this type of fracture is not effected ". In 1916 Cotton and Henderson, in a forthright paper, wrote : " Ordinarily speaking, the man who breaks his heel bone is ' done ', so far as his industrial future is concerned." They ended their paper with the following conclusions : " (1) Conservative treatment gives incredibly bad results. (2) We must do better than this : it must be possible. (3) The reduction suggested and practised is a step forward." To-day, conservative treatment is still widely practised and, although the results are not as bad as has been reported, I hope to show that reduction of these fractures is possible and does give better results.

The discussion will be supported by the evidence of a follow-up of all the patients who could be traced, treated between 1941 and 1948 at the Birmingham Accident Hospital (241 fractures) and an additional series (25 fractures) containing only cases with significant displacement treated by reduction during 1949 and 1950. After follow-up, and rejection of incomplete cases, there are 220 fractures in which the results of treatment have been determined or could be accurately assessed. Of the 79 cases reduced, I have been responsible for 31.

## CLASSIFICATION

The fact that at least two types of fracture of the calcaneus occur was recognized by Malgaigne as long ago as 1843, but it was not until Böhler's (1935) classification was published that there was general appreciation of the relationship between the type of fracture and the prognosis. His groups are arranged in order of increasing severity in terms of prognosis. In practice, the likelihood of future disability brings the major division between fractures in which the posterior subtaloid joint is involved or displaced, and those in which it is not. For this reason the classification I shall adopt in this paper, although it covers the same groups as Böhler's, will divide the cases into these two main classes (*Table I*). Fracture into the joint form the assorted batch called ' crush ' or ' squash ' fractures. This term, although descriptive, is misleading because it suggests an ill-defined medley of breaks, whereas, in fact, two definite and constant patterns of fracture occur which are closely related to each other in mechanism, and their recognition makes the complicated radiological appearances easier to interpret. Less than 4 per cent were so grossly comminuted that the original pattern could not be exactly determined. In 15 per cent of the recognizable types gross comminution was present, but many of these had completely successful reductions. The major part of this paper is devoted to these fractures into the posterior subtaloid joint, with brief reference first to those lesions which do not involve it.

*Table I.*—Classification of All Cases of Fractures of Os Calcis (1941–1948)

| | Percentage | No. of Cases |
|---|---|---|
| *Not involving Subtaloid Joint* :— | | |
| Tuberosity fractures | | |
| Beak type (Boyer) | | |
| Avulsion medial border | 17·4 | 42 |
| Vertical | | |
| Horizontal | | |
| Involving calcaneo-cuboid joint | | |
| Parrot nose type | 4·6 | 11 |
| Various | 3·3 | 8 |
| Total | 25·3 | 61 |
| *Involving Subtaloid Joint* :— | | |
| Without displacement | 15·4 | 37 |
| Tongue-type, with displacement | 19·9 | 48 |
| Centro-lateral depression of joint | 32·8 | 79 |
| Sustentaculum tali fracture alone | 0·4 | 1 |
| With gross comminution | | |
| From below | 3·7 | 9 |
| (Including severe tongue and joint depression types | 15·3 | 37 |
| From behind forward with dislocation subtaloid joint | 2·5 | 6 |
| Total | 74·7 | 180 |

**Fractures not involving the Subtaloid Joint.**—These formed 25 per cent of the series. They correspond to :—

*a.* Böhler's Type 1—rare fractures of the upper border of the body—the so-called ' beak ' fracture of Boyer. After reduction fixation is probably unnecessary, because they are not avulsion fractures by the tendo Achillis, for this is inserted into the tuberosity below the fracture line.

*b.* Böhler's Type 2—an avulsion fracture of the attachment of the plantar fascia to the medial aspect of the tuberosity.

*c.* A few of Böhler's Type 4, where the body is fissured vertically or longitudinally but the subtaloid joint is intact.

* Being a Hunterian Lecture delivered at the Royal College of Surgeons, on March 6, 1951.

*d.* A type Böhler does not mention, in which the superolateral spur at the front of the bone is knocked or pulled off: this fracture is really part of a severe inversion-adduction strain of the foot, and was first described by Dachtler in 1931.

*Results* (*Table II*).—Of these 61 cases 47 were either followed up or sufficiently well documented for the results to be recorded. These are universally good—92 per cent back to their full work in under six months, 93 per cent stabilized to their final condition in six months, and 93 per cent with none or only trivial symptoms. Dividing the cases into those treated by plaster and those treated by exercise, the figures for return to work and recovery to stability are a little in favour of exercise.

*Table II.*—Os Calcis Fractures not involving Subtaloid Joint. Results of Cases followed up

| No. of Cases | Plaster (27) | | Exercises (20) | | Total (47) | |
|---|---|---|---|---|---|---|
| | No. | Per-centage* | No. | Per-centage* | No. | Per-centage* |
| Return to work : | | | | | | |
| under 3 months | 13 | 62 | 14 | 82 | 27 | 71 |
| under 6 months | 6 | 91 | 2 | 94 | 8 | 92 |
| under 12 months | 2 | 100 | 1 | 100 | 3 | 100 |
| Not known | 6 all women | | 3 | — | 9 | — |
| Time for recovery : | | | | | | |
| under 3 months | 12 | 54 | 15 | 79 | 27 | 66 |
| under 6 months | 9 | 95 | 2 | 89 | 11 | 93 |
| under 9 months | 0 | 95 | 0 | 89 | 0 | 93 |
| under 18 months | 1 | 100 | 2 | 100 | 3 | 100 |
| Not known | 5 | — | 1 | — | 6 | — |
| Symptoms : | | | | | | |
| Nil | 21 | 80 | 14 | 82 | 35 | 81 |
| Trivial | 3 | 11 | 2 | 12 | 4 | 12 |
| Disabling for recreation | 2 | 8 | 1 | 6 | 3 | 7 |
| Not known | 1 | — | 3 | — | 5 | — |
| Examination : | | | | | | |
| Normal | 23 | 92 | 16 | 100 | 39 | 95 |
| Stiff | 2 | 8 | — | — | 2 | 5 |
| Not known | 2 | — | 4 | — | 6 | — |

* Percentage is total of known cases.

**Fractures involving the Subtaloid Joint.**—It is the group of fractures involving the subtaloid joint that merits the major attention, for this is where the results are liable to be so bad. There is no doubt that from every point of view they appear difficult to handle, but if, from our knowledge of the mechanism of the injury, we can discover the pattern of the fracture in the bone and its appearance on the X-ray shadow, we can build a mental picture of the bony and soft-tissue wounds. As in all other fractures the closure of these wounds, both bony and soft-tissue, will be found to depend on a key manœuvre which retraces the path of the displacement, and reduction becomes a logical stage in treatment. When bony reduction is exact, soft-tissue tears will be closed and heal with minimal periarticular fibrosis. In the treatment of the damage to the soft tissues, the rival claims of immobilization of the fracture and exercise of the foot must be respected. As Böhler (1935) remarked: "Fractures of the calcaneus should be treated like all other fractures, i.e., exact reduction must be made and the reduced fragments must be fixed in position until bony union has occurred, and during the period of fixation as many joints as possible should be exercised." Philip Wilson (1938), in his text-book, however, speaking of Böhler's (1931) *technique* of reduction, wrote that "the position of the fragments may be improved, but complete reduction, using the term in the sense in which it is employed in speaking of fractures elsewhere, is rarely if ever obtained".

## X-RAY INTERPRETATION

**The Normal Os Calcis** (*Fig.* 559).—The normal os calcis has a number of features on radiological examination which are important to an understanding of fracture anatomy. There is a strong and thick cortical strut extending on the upper and outer side from the front of the bone to the posterior margin of the posterior subtaloid joint. This strut is angled and the angle supports the sharp lateral spur of the talus. This angle, with the wedge just above it, is of considerable importance and has been termed the 'crucial angle' by Gissane (1947). The internal structure of the bone is largely spongy, and the lines of its trabeculæ may be expected to conform exactly to the major lines of compression and traction stress to which the bone is normally subjected (Koch, 1917). The main compression struts run downwards and backwards from the joint surface, and downwards and forwards from the strong lateral cortical buttress. The traction trabeculæ run backwards from the lower border of the body and turn upwards into the tuberosity, and are responsible for taking the levering strain as the tuberosity is pulled up by the tendo Achillis for the take-off in walking. The sustentaculum tali on the inner side can be seen in outline as an oval structure partly hidden by the horizontal upper buttress of the bone.

In the axial view the appearance of the subtaloid joint will depend on the angle at which the rays strike it, and it is often not shown at all. The sustentaculum tali can be seen as a shelf on the inner side supported by a curved angle bracket of strong cortical bone. The anterior subtaloid joint between the sustentaculum and the talus is farther forward and higher than the posterior, and in this view this difference in level can usually be seen. On the outer side the cortex is very thin. The trabeculæ are in the main parallel to the axis of the bone.

Variations in the appearance of the bone in axial views and the interpretation of abnormality can cause very great difficulty until it is appreciated that the view is not an anteroposterior projection but an oblique one. To try to demonstrate this, corresponding photographs and radiographs have been mounted beside each other (*Fig.* 560). The main change in appearance obtained by altering the angle is one of lengthening or foreshortening the body. Unless the rays strike the joint tangentially its outline will not show against the mass of spongy bone. Furthermore, if the joint is simply displaced downwards and forwards—that is, in the line of the X-ray tube—no deformity may be apparent. Similarly, gross flattening of the os calcis with upward displacement of the tuberosity may give the appearance only of foreshortening.

There are two more features of X-ray diagnosis in the lateral view which often give rise to difficulty:

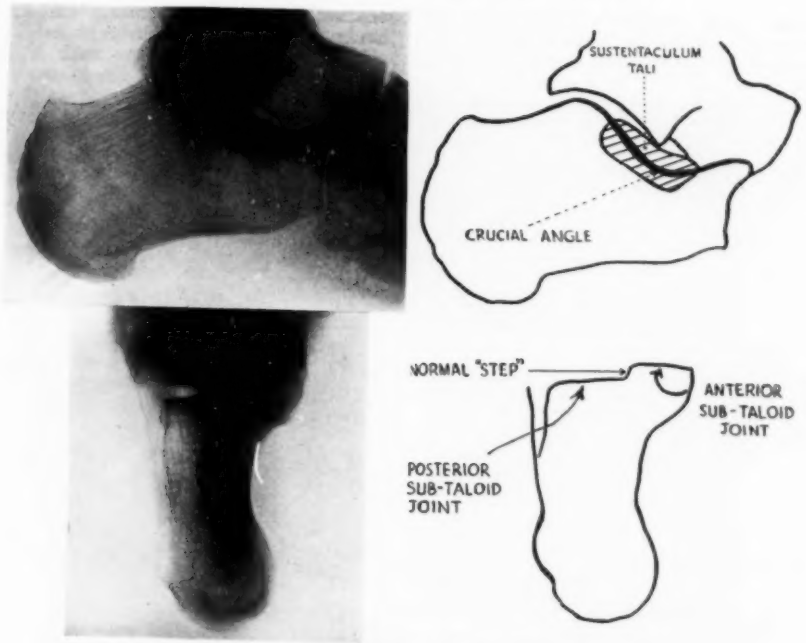



FIG. 559.—Normal os calcis. Lateral and axial views.

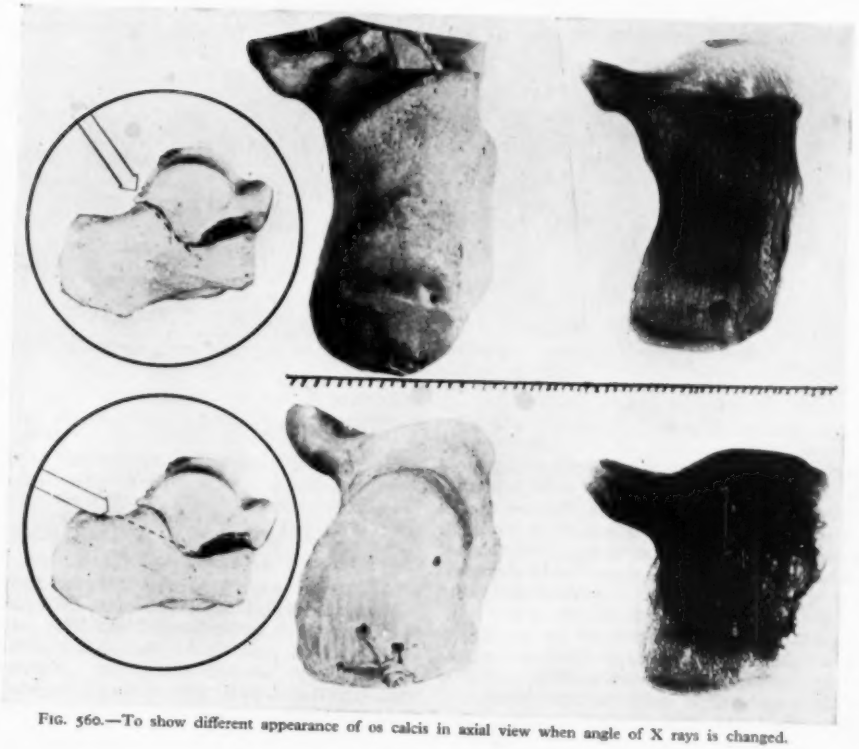


FIG. 560.—To show different appearance of os calcis in axial view when angle of X rays is changed.

1. *Inversion and Eversion* (*Fig.* 561).—The X-ray appearance of the os calcis changes as it moves through its complicated normal range of movement on inversion and eversion. Viewed from the lateral side, as the foot inverts the sustentaculum comes into view above the outer cortical buttress and blocks the clear shadow of the posterior subtaloid joint. In eversion the reverse is true—the sustentaculum moves downward below the horizon of the buttress. In each case the outline of the saddle-shaped posterior subtaloid joint changes a little, but the crucial outer half of it will always be that portion which fits the concavity of the well-focused joint surface of the talus passing down to the sharp spur. It should particularly be noticed how the taloid spur descends into the crucial angle at the limit of eversion.

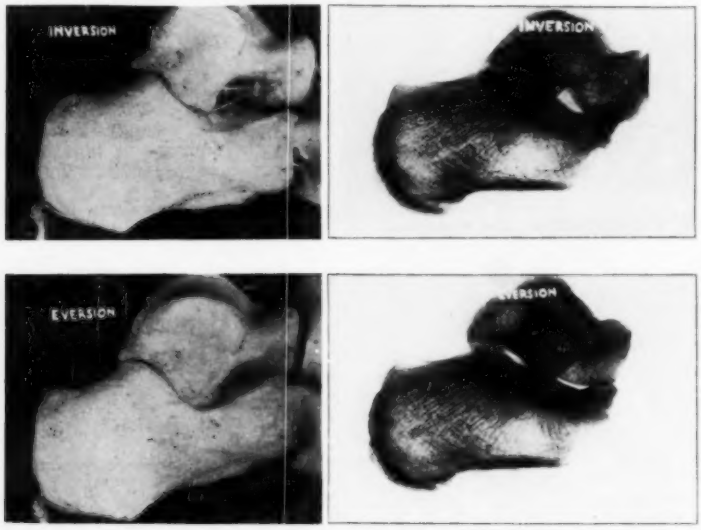
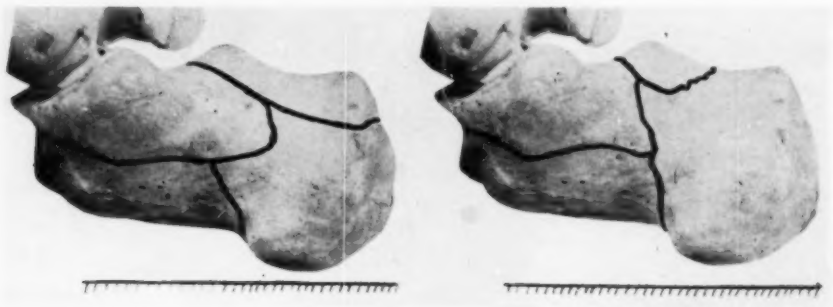



FIG. 561.—To show different appearance of os calcis in lateral view in inversion and eversion.

2. *X-ray Technique.*—The outline of the subtaloid joint on the outer side is quite different from that on the inner (*Figs.* 561, 562) where the square, more anteriorly-placed sustentaculum tali is the prominent landmark. An X-ray plate, placed on the inner side (as when X-raying the ankle), will show the inner aspect of the bone in better focus because it is nearer the plate (*see Fig.* 570). It is necessary, to avoid confusion, always to have the plate on the outer side of the foot, so that the outer part of the bone is in focus, but it is wise to be familiar with the other less usual view.



A B

FIG. 562.—Pattern of fissuring on inner side of bone. A, In tongue type fracture; B, In joint depression type.

## MECHANISM AND X-RAY INTERPRETATION

This preamble has been intended to help to an understanding of the mechanism of injury and its interpretation on the X-ray film. The patient drops and lands heavily on his feet. The momentum of his body is carried along the tibia, transmitted through the talus by two routes, outer and inner, to the calcaneus.

1. *The Outer Route* (*Fig.* 563).—The posterior subtaloid joint is immediately forced into eversion, and the sharp outer taloid spur is driven like an axe into the crucial angle, splitting it and the outer wall of the bone along its grain. This fracture is fairly often seen after minimal fracturing force.

2. *The Inner Route* (*Fig.* 562).—The remainder of the force then descends through the anterior subtaloid joint on to the sustentaculum tali, which may be sheared off the inner side of the body together with the medial one-third or one-half of the posterior subtaloid joint surface. This pattern of fissuring is remarkably constant and, with minor variations and subsidiary lines of cleavage, is to be seen in practically every case. If the body momentum is expended or removed at this point, part or all of this fissuring is the fracture we see, but if it continues one of two types of displacement will occur. In the first, the tongue type, the secondary fracture line runs straight back to the posterior border of the tuberosity. In the second, the joint depression type, it runs across the body just behind the joint.

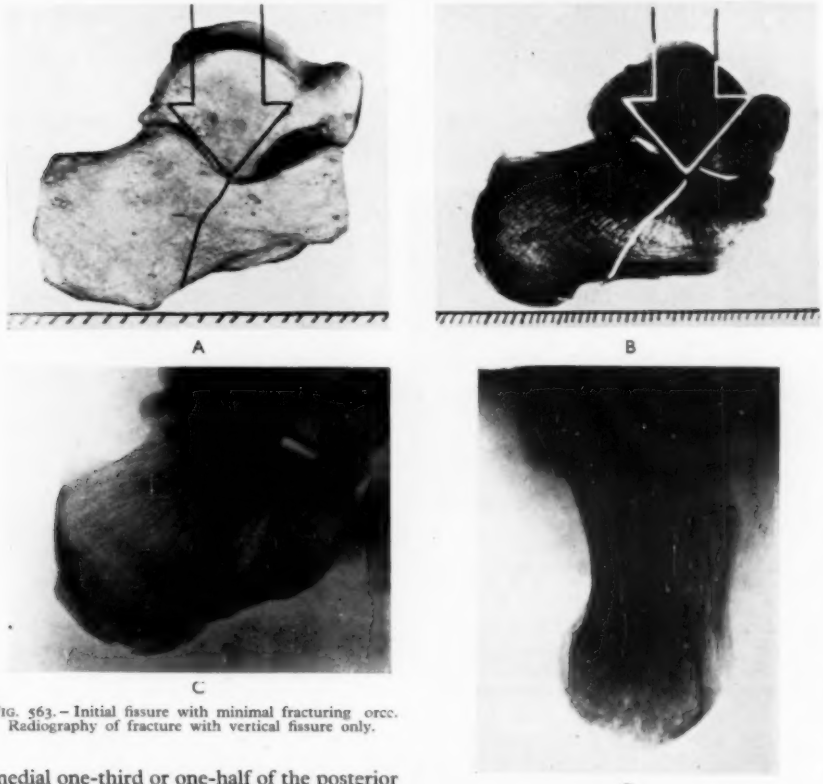



FIG. 563. – Initial fissure with minimal fracturing force. Radiography of fracture with vertical fissure only.

**1. The Tongue Fracture.**—In this pattern, with the secondary fracture line running straight back to the posterior border of the tuberosity from the crucial angle, further descent of the talus will depress into the cancellous bone of the body, the anterior end of this large fragment consisting of the outer half of the posterior subtaloid articular surface and the upper border of the body (*Fig.* 564). If at this stage the medial sustentacular component has not fractured, the descent of the outer half alone can occur by eversion of the heel. The reconstructed picture corresponds to a degree of displacement seen quite often in patients, and the sustentacular component at this stage often remains intact. This degree was described clearly by Malgaigne in 1843 in a well-known specimen obtained at post-mortem. Böhler (1935) and Palmer (1948) both describe this stage, but Palmer, in a most excellent presentation of the mechanism and pathological anatomy, regards the shearing fracture of the sustentaculum tali and inner portion of the posterior joint as the primary break, dividing the bone into two portions, medial and lateral. In practice, a study of a number of cases with these early stages proves that this is not necessarily true, and that the first stage in the vertical fissure on the outer side from the crucial angle to the lower border is caused by the axe-like descent of the spur of the talus.

The final stage is seen when the force continues (*Fig.* 565). The front end of the tongue is driven farther down, but now the tuberosity, still in contact with the ground, is forced upwards and backwards relative to the body. It separates from the body as the primary fracture line opens up. The upper

tongue, pinned down in front inside the lateral wall by the lateral apophysis of the talus, pivots, as Morestin (1902) pointed out, " like a see-saw, down at the front and up at the back ". " It is here ", he rightly added, " that the attack must be made, for this is the chief lesion." Malgaigne shows a picture of this degree of displacement in his atlas and when deformity is extreme the step between the inner and outer components of the subtaloid joint is readily visible. The main features of the axial view, however, are the ballooning and comminution of the lateral wall with the depressed fragment lying inside, and the fracture of the sustentaculum tali

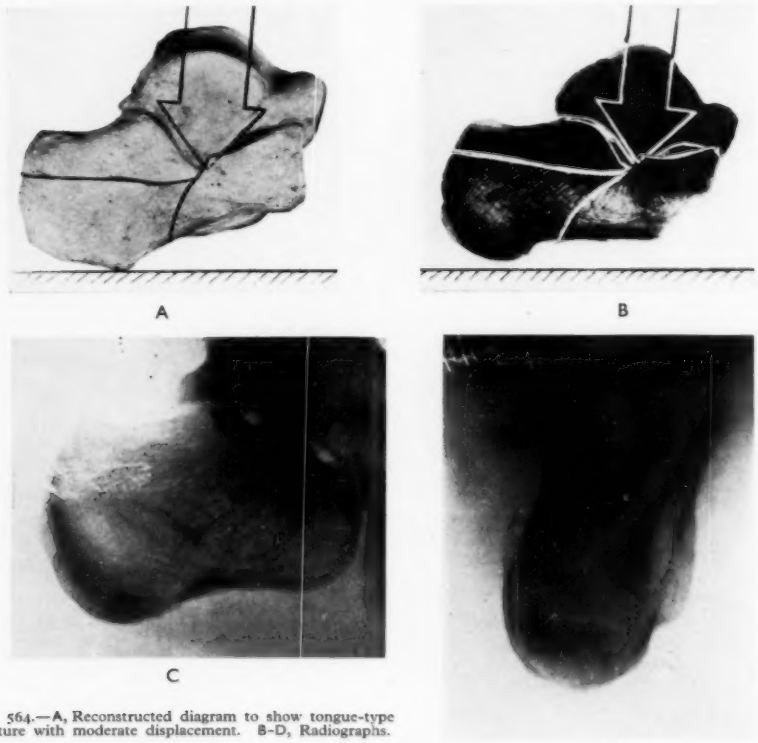



FIG. 564.—A, Reconstructed diagram to show tongue-type fracture with moderate displacement. B-D, Radiographs.

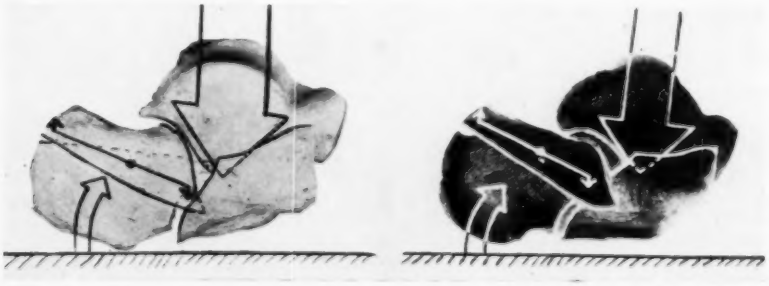


FIG. 565.—Reconstructed diagram to show severe tongue-type fracture with secondary upward displacement of tuberosity.

it resembles the reconstruction very closely (*Fig.* 566). Notice how the tongue is depressed *inside* the lateral wall of the body.

In the axial view (*Fig.* 567) the fissuring in the early stage may not show on the radiograph, but along which the medial part of the bone has been driven downwards and inwards. In addition there will be foreshortening. Such cases with secondary upward displacement of the tuberosity form most of the severely comminuted fractures in this type.

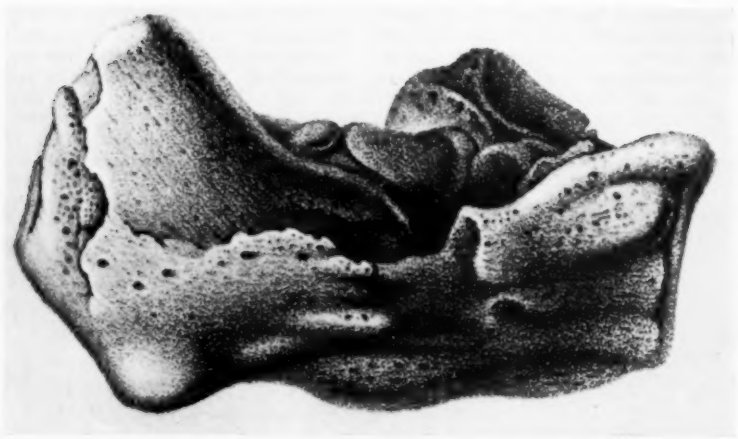


FIG. 566.—Severe displacement in tongue type fracture. (*After Malgaigne.*)

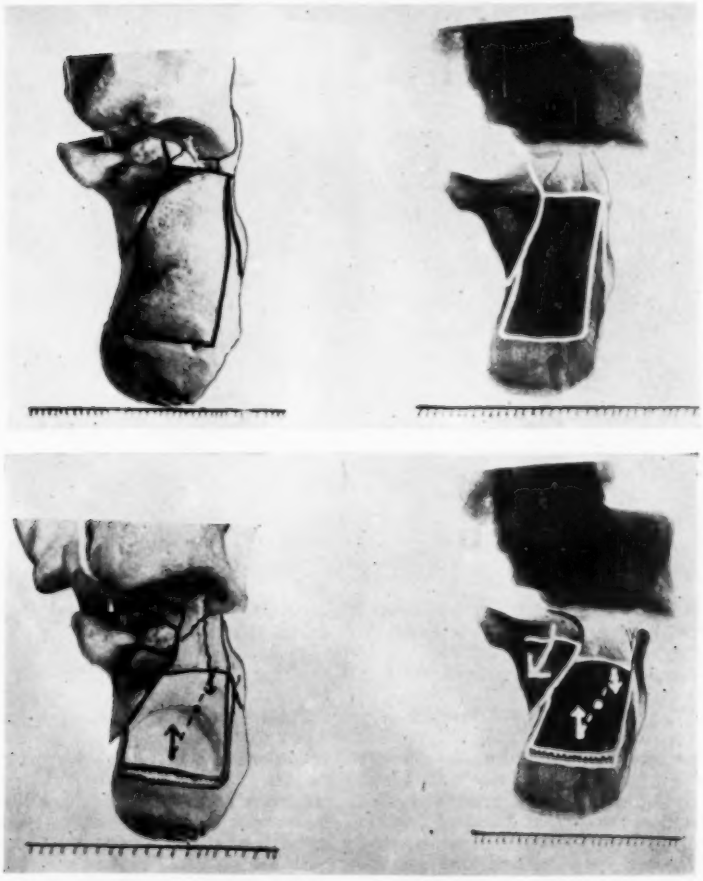



FIG. 567.—Axial views of tongue type fracture. A, Pattern of fissuring in tongue type fracture without displacement. B, Appearance of displacement showing step between medial component and lateral displaced tongue.

In the patient shown in *Fig.* 568 A, B the displacement and upward movement of the tuberosity can be seen, matching the built-up picture evolved from the mechanism. In the axial view the joint surface can clearly be seen displaced and rotated. After reduction by an " attack on the chief lesion ", the hollow beneath the displaced fragment where the cancellous bone has been crushed becomes visible

The earliest stage without displacement occurs with a minimal fracturing force, and the later degrees closely resemble the tongue variety, except for the absence of the long lever. The radiographs shown in *Fig.* 570, with minimal displacement, were taken from both sides and the two for comparison show the different outline of the joint. When the fracturing force continues the joint fragment is

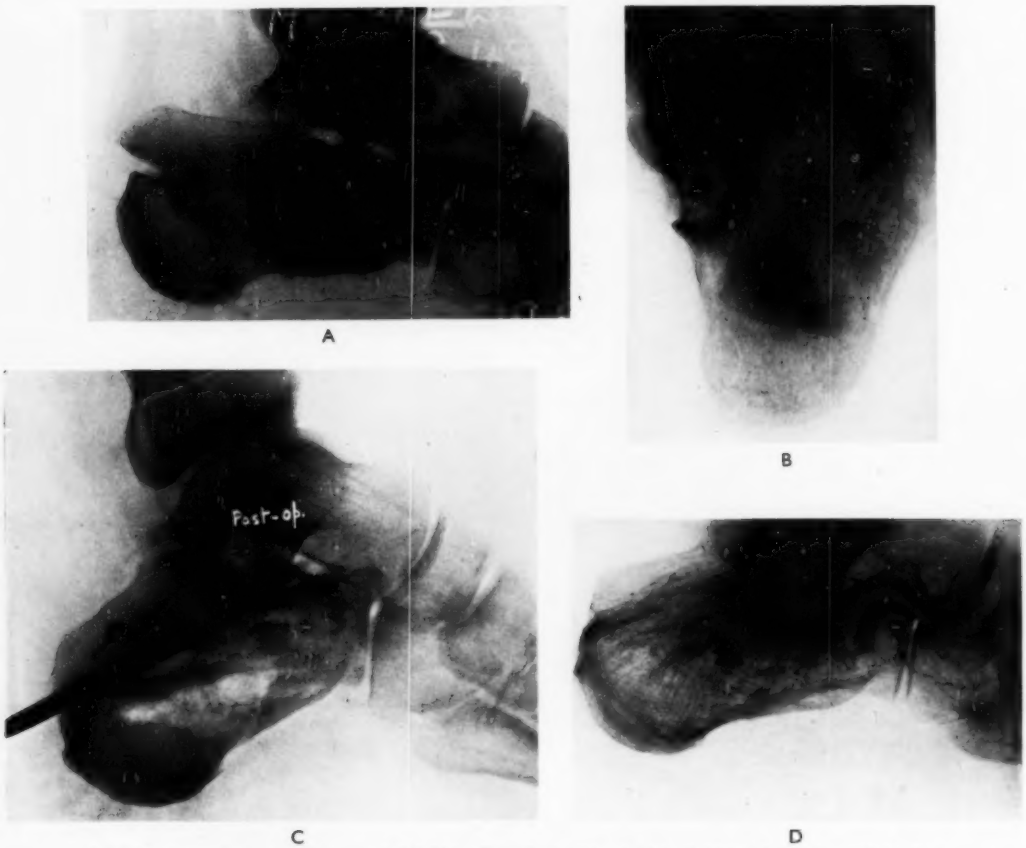



FIG. 568.—Severe tongue type fracture. A, B, Initial radiographs, lateral and axial ; C, After reduction by saggital spike ; D, Union and retrabeculation after one year.

(*Fig.* 568 C). The exact restoration of the crucial angle is evident and the joint line and relationship are normal. After one year the os calcis has consolidated and is well calcified. The joint space is normal (*Fig.* 568 D).

**2. The Joint Depression Type.**—There is very little variation in pattern from the tongue type, but the distinction makes a very great difference to the treatment. The secondary fracture line runs across the body just behind the joint, so that, in the subsequent displacement, the fragment involved consists of a well-defined, unbroken piece of bone carrying the articular cartilage of the outer half to two-thirds of the posterior subtaloid joint (*Fig.* 569). This type is more common than the tongue fracture.

depressed into the spongy bone of the body inside the lateral wall, which is driven outwards (*Fig.* 571).

In this depression it tends to hinge downward and backward on its posterior fracture line, along which the soft tissues remain intact, so that, after reduction, when the tension is taken off this hinge, there is little danger of its blood-supply being cut off. This pattern is common, and in *Fig.* 579 A, B the joint fragment can clearly be seen depressed into the body, with the primary fracture line present but not opened up. The tuberosity is in normal alinement with the body. The axial view shows the shearing fracture of the sustentaculum with displacement and bulging of the lateral wall.

The final stage (*Fig.* 572) resembles that in the tongue variety—the tuberosity has now been driven up as a secondary displacement, and the primary fracture line has been opened up. This secondary displacement must be recognized, for unless it is looked for and arrangements made for its correction during reduction the fracture jig-saw will not fit properly.

Such a fracture in a patient (*Fig.* 573) would be regarded as a severely comminuted one, and it might be expected that the complete separation of the joint fragment from its surroundings would jeopardize its blood-supply. Watson-Jones (1940) regards avascular necrosis as a common sequel to all fractures of the os calcis, and in this pattern its danger is evident.

In the axial view (*Fig.* 574) again the simple fissuring may show little against the background of the bone, but the sustentacular fracture will be evident when present. After displacement, foreshortening

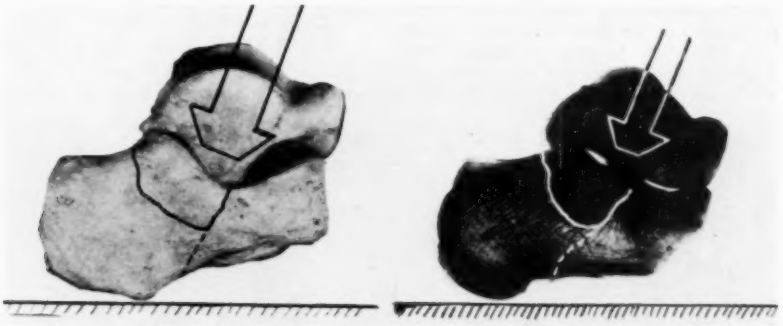
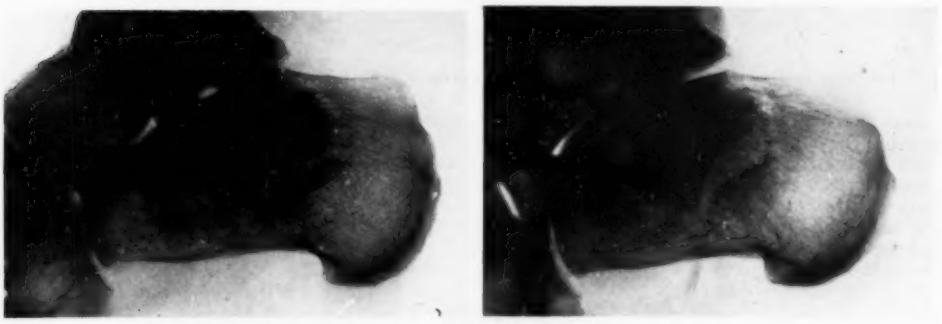


FIG. 569.—Joint depression type of fracture. Fissuring after minimal fracturing force.



A B

FIG. 570.—Radiographs of joint depression type fracture without displacement to show different outline of joint when plate is placed on (A) outer side, (B) inner side.

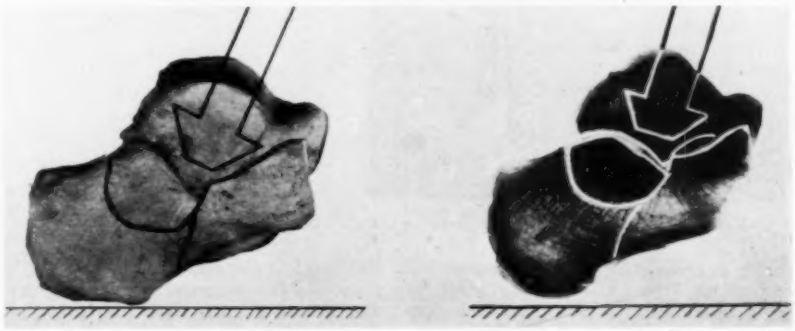


FIG. 571.—Joint depression type of fracture with moderate displacement.

is the main feature when the tuberosity has moved up ; the sustentaculum has moved down and in, and the step is usually visible.

**Reason for the Step in the Joint.**—The descriptions of the fracture given by Malgaigne in the case of the tongue pattern, and Lériche (1929) and others in the case of the joint depression, make it clear that a clean step varying in height from 3–10 mm. is always found between the outer and inner parts of the posterior subtaloid joint. In effect this step lies between the sheared-off inner component and the outer crushed half of the bone : and the latter only very rarely shows comminution. As the bone as a whole is crushed it is difficult to account for the definite difference in level when the case is examined.

Palmer (1948) has studied this point and has shown that it results from elastic recoil when the fracturing force is removed. At the moment of greatest compression the sustentacular half is depressed down to the level of the outer half, but on release the soft tissue resilience in the foot causes the sustentacular half to be drawn up by its intact attachments to the talus. The outer half of the bone, buried in the body inside the lateral wall, no longer has any attachment to the talus and remains depressed. The height of the step is therefore a measure of the recoil which has occurred. This fact has a significance in treatment, for the depressed fragment, once lifted into line with the inner half, will require little force to maintain it in position. The clean division of the joint into two pieces without comminution, which is almost the rule, suggests that an exact reduction will minimize the danger of subsequent arthritis.

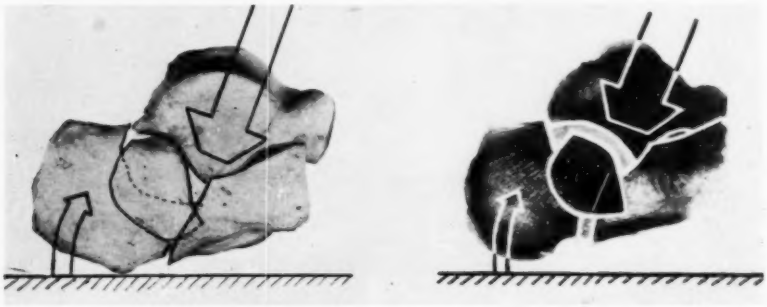


FIG. 572.—Joint depression type of fracture. Severe depression with secondary upward displacement of tuberosity.

## CLASSIFICATION OF FRACTURES INVOLVING THE SUBTALOID JOINT

The classification is now straightforward. A similar mechanism produces two distinct, but closely related patterns, in which the various degrees according to severity are of little practical importance. In considering treatment, however, it is essential to differentiate between the tongue type, in which the displaced key fragment can be manœuvred by using the long lever ; and the joint depression type, where the displaced fragment buried in the body of the bone can only be reduced by an open approach.

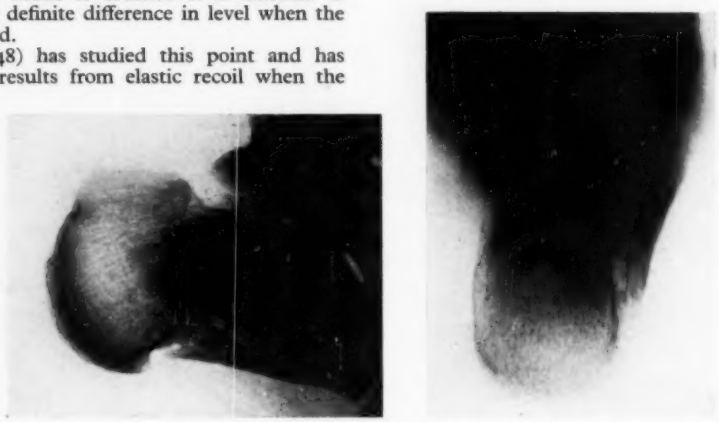


FIG. 573.—Radiographs of severe joint depression type of fracture with secondary upward displacement of tuberosity.

## TREATMENT

The history of the treatment of fractures of the calcaneus is one of divers attempts to improve the end-results, and the multitude of suggested methods of reduction is evidence of the dissatisfaction which prevails. Most of these have been gathered together

by Goff (1938) and he has filled two pages with small pen drawings of the different methods. Many of these advocate the use of more and more powerful leverage, and the literature shows that it is on efforts to apply greater force that many surgeons have relied. In fact, very little force is ever needed, and sufficient the spring and mobility of youth are more or less absent on the normal side, attempts at reduction are ill advised. It has been found that if the long-acquired tolerance to stiffness is accepted, immediate exercise therapy to restore pre-accident function, even in deformity, produces much better results.

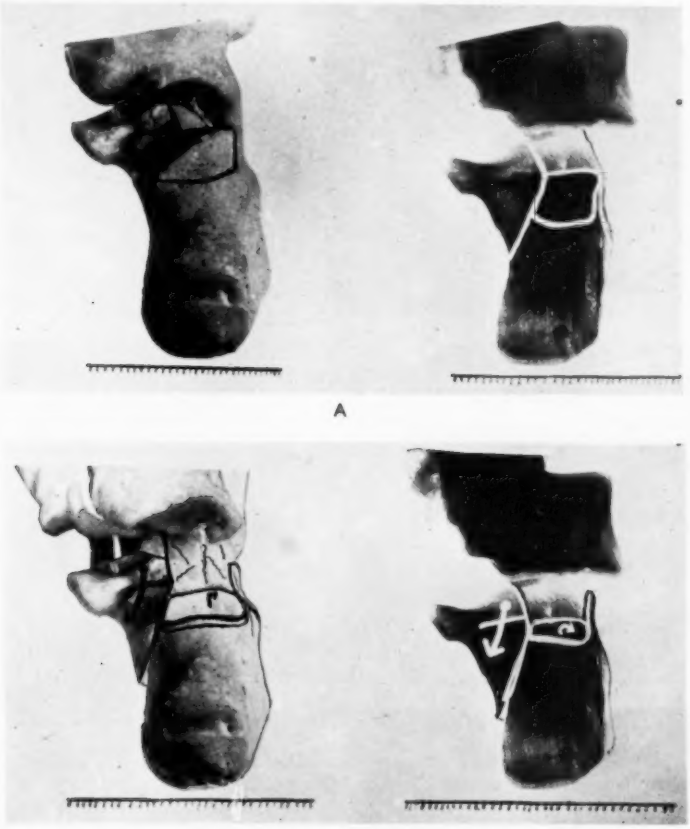



FIG. 574.—Axial views of joint depression type of fracture. A, Pattern of fissuring; B, Displaced variety to show step between medial sustentacular component and depressed joint surface.

is now known of the mechanism and pathological anatomy of this injury, and of the results of the many different forms of treatment, for the surgeon to be eclectic, and in deciding for a given case, the aim and objective of the treatment must be kept clearly in mind. In considering this, the pre-accident condition of the foot is of fundamental importance.

**Influence of Age on Treatment.**—As age advances, loss of elasticity in the ligaments causes a gradual loss of resilience in all structures. From one person to another this degree of stiffness at any age will vary greatly, and it is interesting that fractures of the os calcis in older people are more common in those with stiff feet, and result from more trivial injuries. Relatively immobile feet tolerate immobilization badly, and in patients over 50 where Muscle and ligamentous compensation, developed over years, is very easily lost.

The immediate effect of a smash fracture of the os calcis with displacement is to produce a traumatic flat-foot, which is associated with extensive bruising of the sole of the foot and soft-tissue tearing and bruising around the mid-tarsal and subtaloid joints. The deformity of the traumatic flat-foot is different from that of the ordinary flat-foot (Böhler, 1935), but produces the same effects, and this, combined with subsequent fibrosis around the joints, leads to loss of suppleness and resilience. In youth, this sudden deformity, unless corrected, has the effect of prematurely ageing the foot. Few things are more depressing than to see a healthy young man in his twenties, shuffling slowly and cautiously on

a rigid, painful, and 'old' foot. The case shown in *Fig.* 575 is a tragedy of failure in treatment: the patient had been standing on the deck of a submarine when a mine exploded, and the jar of the deck smashed both his os calces, and his tibiæ. There is no information about treatment, but when seen at hospital after discharge from the Service he limped painfully into the clinic on these prematurely aged, painful, and deformed feet. *He* was finished, as far as his industrial and athletic future was concerned. At 23 he is a cripple, condemned to two sticks and a sedentary life.

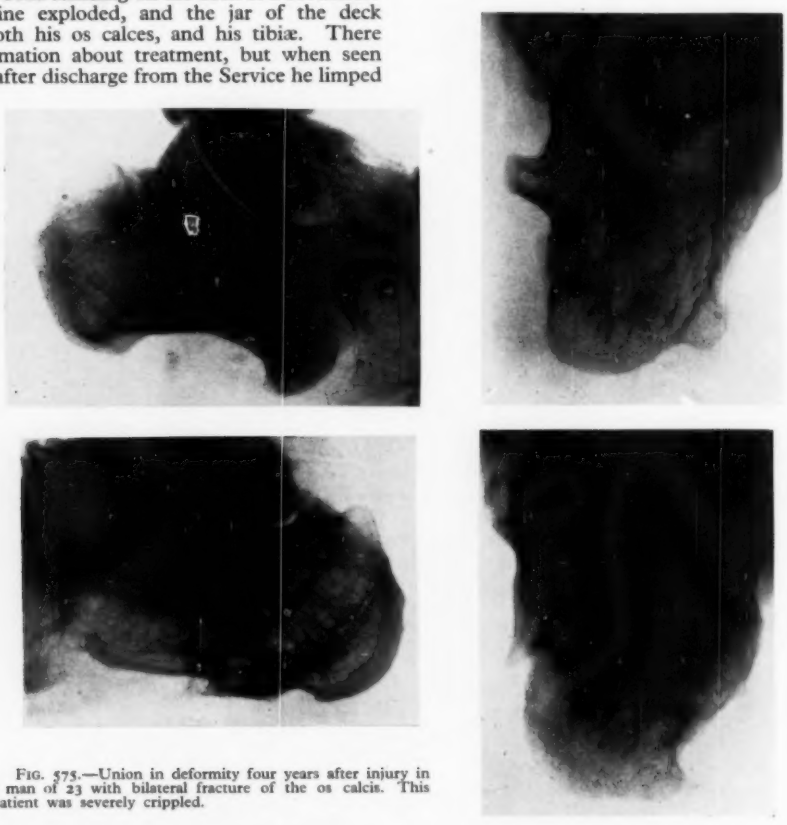
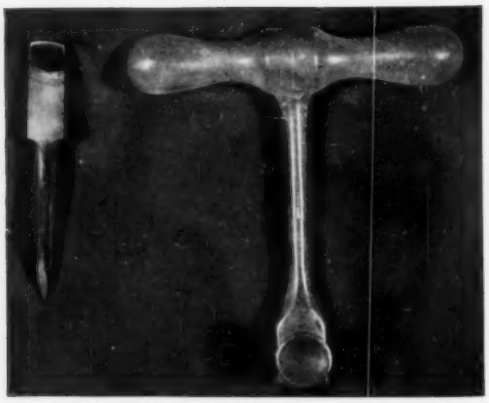


FIG. 575.—Union in deformity four years after injury in a man of 23 with bilateral fracture of the os calcis. This patient was severely crippled.

For the patients under 50 with displaced fractures the treatment recommended here is a combination of exact reduction, of maintenance of that reduction,



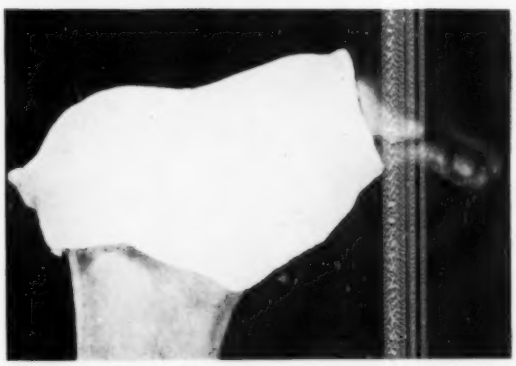
A

B

and exercise of the ankle, subtaloid joint, and mid-tarsal joint from the beginning. It is proving successful and it is easy to carry out, and the work of those who established the principles must be acknowledged. Open reduction, as far as I can tell, was first advocated by the French. Morestin in 1902 appears to have been the earliest to recognize the key nature of the tongue fragment: he made a lateral approach, lifted the fragment, put it in a good position, and termed the process 'modelling the foot'. In 1929 the French literature contains an interesting succession of papers (Lériche; Lenormant, Wilmoth, and Lecoeur; Wilmoth and Lecoeur; Bérard; and Cotte) in which the main discussion is whether the reduced fragment should be maintained by a staple or by a bone-graft, and in these papers extremely good results are reported in under three months. Simon and Stultz (1930) and Palmer (1948) have both practised this method with success.

A brief reference must be made to a paper by Westhues which appeared in Germany in 1934; it referred to a closed reduction by the use of a saggital nail introduced into the os calcis, "and with its assistance one is able to perform with extreme ease almost an anatomical reduction". Ehalt used this method and in 1937 and 1940 published the details.

FIG. 576.—Technique of closed spike reduction. A, The Gissane spike and introducer; B, The spike inserted into displaced fragment; C, Reduction of fracture (*Note*: The left hand under the toes is not correctly placed); D, Transverse compression; E, Completed shoe-plaster incorporating spike.



E

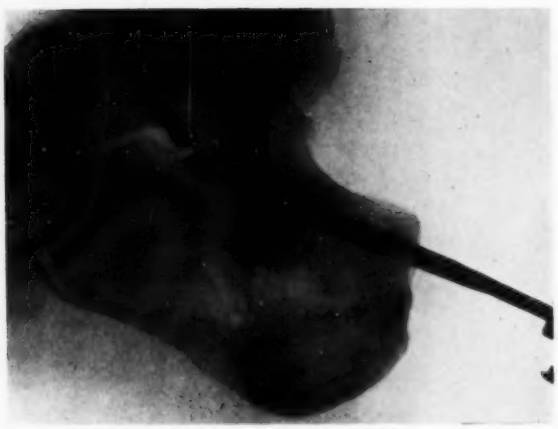
It is to William Gissane, who introduced the method to this country, that the credit for the development of the reduction technique must go: he proved its value and designed a special spike and handle to facilitate its use (*Fig.* 576 A). He soon found that this closed method was suitable only for the tongue type of fracture, for the spike had no control over

the separated and depressed joint fragment, and he introduced open reduction maintained by the spike. Both methods (open reduction and the closed reduction by spike), although they achieved good reductions, suffered from the disadvantage that post-operative fixation in plaster appeared necessary, and after immobilization some feet were very stiff. The

A

B

C



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E

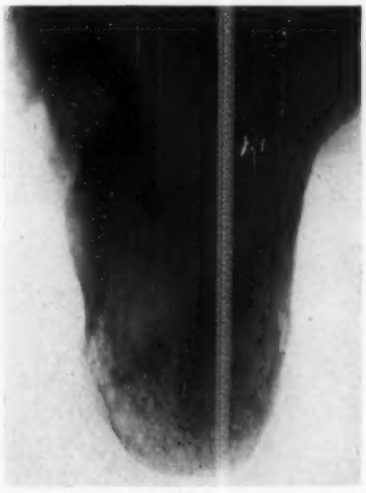
F

history of the value of exercise in this injury with its advantages over fixation in plaster has been difficult to unravel. Bailey, of Oregon (1880), seems to have been the first to recommend elevation, lotions, and no splints, but he adds that the feet were always stiff. Myers (1933) placed great emphasis on early exercise after elevation, and a number of reviews of results refer to " no treatment ", or to the " physiological " method of treatment, or to " supervised neglect ". Bankart (1942) blames the bad results on the immobilization. Certainly there is little

doubt that early foot exercise produces better results than plaster immobilization, and the maintenance of a reduction by any means must provide for movement of the subtaloid and mid-tarsal joints from the beginning if it is to be fully successful.

**The Shoe Plaster** (*Fig.* 577 I).—For these reasons I have during the last nine months been using a small shoe-shaped plaster to hold the spike after reduction, and this, as I shall show, enables ankle, subtaloid, and mid-tarsal joint movements to begin the day after operation. The small force necessary to hold the reduction is found to be amply provided by this small plaster and not even the most unstable fracture has yet become displaced during exercise. This shoe-plaster has only so far been used in 10 cases, but the results are so encouraging that I would crave your indulgence for reporting it to-day. The treatment, then, is an endeavour to combine all the features one would expect to produce good results—exact reduction of all deformities in bone and soft tissues, minimum additional trauma, adequate fixation, and immediate exercise of the joints which normally tend to become stiff.

G



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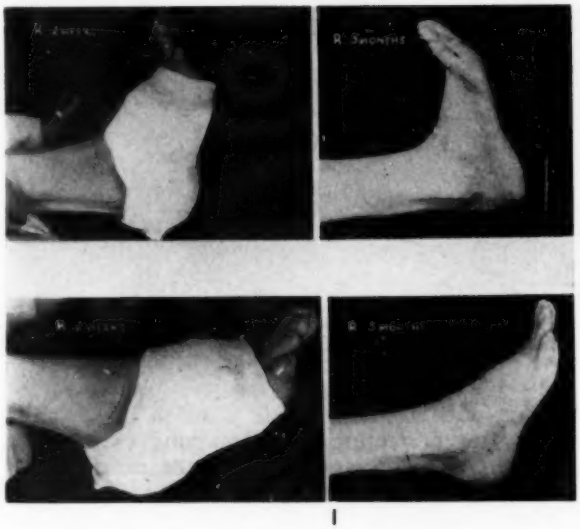
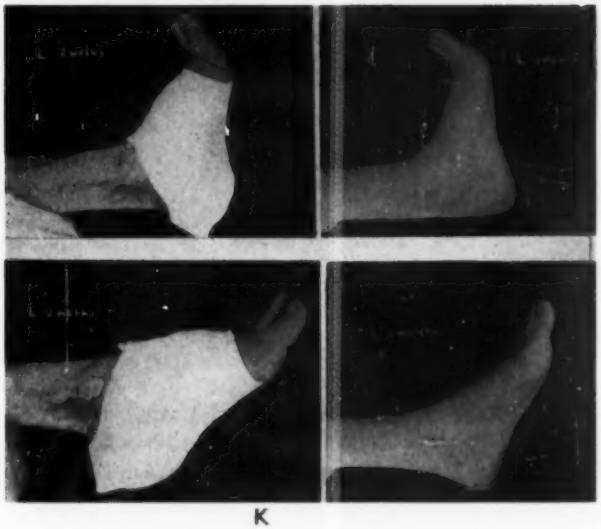


I



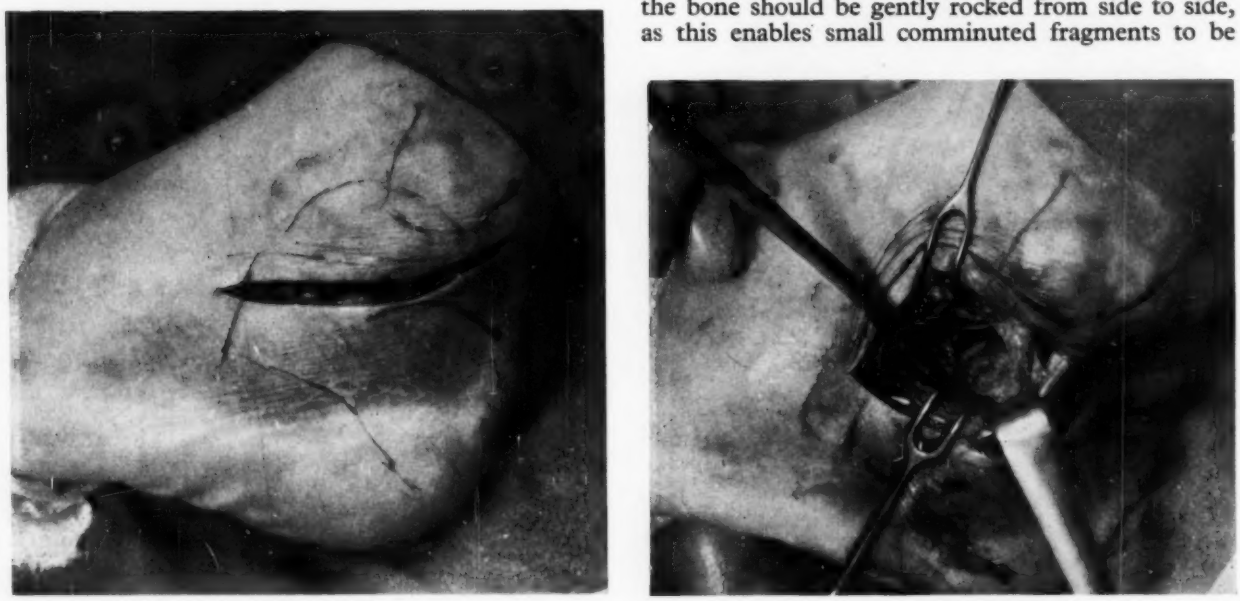
K

L

FIG. 577.—Severe tongue type fracture showing steps of reduction. A, B, Initial radiographs; C, Spike inserted into displaced tongue fragment; D, Appearance after reduction; E, F, Lateral and axial views in plaster; G, H, Radiographs at five months to show union and retrabeculation; I, K, Ankle movement of left and right feet in plaster and at five months; L, Inversion and eversion in plaster and at five months.

## TECHNIQUE

**1. Tongue Type.**—The principle is to insert a Gissane os calcis spike in the long axis of the displaced fragment, and to use this lever to replace the tongue in its correct alinement with the taloid component of the posterior joint. These spikes are made in two lengths, and the shorter is suitable for this type of case. At the same time the downwardly displaced sustentacular portion which remains attached to the talus by its ligaments is elevated by traction on the talus in the manner to be described presently. It is found that the upwardly displaced tuberosity will fall back into its correct relation to the body as the tongue fragment is rotated.



A B

FIG. 578.—Technique of open reduction in joint depression type of fracture. A, Incision; B, Elevation of depressed joint surface. (*Note*: The lower hook retractor holds out the lateral wall of the os calcis, which has not been stripped of its soft tissue attachments.)

*a*. The patient is anæsthetized and placed on the operating table in the prone position. The surgically-prepared heel is palpated on the outer side of the tendo Achillis to determine the position of the upper border of the displaced piece of the tuberosity. After making a small skin incision, the spike, attached to its handle, is introduced from behind forwards into the long axis of the fragment (*Fig*. 576 B). The angle of introduction is judged from the radiographs (*Fig*. 577 A, B), and should be slightly outwards towards the lateral wall of the calcaneus. A check radiograph at this stage is necessary to ensure that the spike is well placed (*Fig*. 577 C).

*b*. The knee is now flexed to a right angle and, holding the forefoot in one hand and the handle of the spike in the other, reduction is effected very easily by lifting the knee just clear of the table (*Fig*. 576 C). During this manœuvre the fragment can be felt to click loose, and the handle and spike will move upwards as the fragment rotates until, as reduction becomes exact, the resistance to movement increases and no further angulation takes place. The weight of the leg and thigh just clear of the table exerts on the talus traction just sufficient to pull the sustentacular fragment into alinement with the body of the os calcis. Thus the posterior joint surface of the talus is used as a matrix or mould to square off the calcaneal joint surface, but it is worth noting that over-reduction is possible.

*c*. The displaced fragments are now lying in their correct relations in the lateral view, and the depressed tongue is once again clear of the bulged-out lateral wall. The heels of the clasped hands are used to press home this wall, to line up the tuberosity and sustentaculum tali, and thereby to reduce the width of the bone to normal (*Fig*. 576 D). At this stage, the bone should be gently rocked from side to side, as this enables small comminuted fragments to be lined up, and the final stable position can usually be felt after correcting any remaining eversion or inversion. A radiograph confirms the exact reduction (*Fig*. 577 D).

There is a small point of technique in the way the foot is held which has, in a few cases with gross comminution, been shown to be of importance. The natural tendency is to lift the foot by the heads of the metatarsals as shown in *Fig*. 576 C. This is wrong, for it causes the foot to plantar-flex at the mid-tarsal joint—that is, to move into cavus. As Böhler has shown, some of the cases with considerable comminution of the body also have a tear of the dorsal capsule of the talo-navicular joint with subluxation. Plantar-flexion at the mid-tarsal joint in these cases will aggravate this subluxation and cause the body to bunch up into a deformed position. To avoid this, the main lift should be applied to the head of the talus and scaphoid by the tips of the fingers, and plantar-flexion prevented by the thumb laid on the plantar surface of the heads of the metatarsals. After the reduction the skin will often be drawn down by the movement of the spike, and it may be necessary to incise it to relieve the tension and to suture the slit above the spike.

*d*. While the reduction is held by an assistant, a thin layer of wool is applied to the foot and a

shoe-shaped plaster applied, incorporating the spike. The purpose of this plaster is to anchor the spike to the under-surface of the calcaneus, and the turns around the foot prevent it riding backwards. The wool is rolled over the edges and the plaster trimmed along the black line. The handle is removed and the spike covered with plaster (*Fig.* 577 I, K). A final radiograph shows that the position has been maintained (*Fig.* 577 E, F). In the axial view the outward direction of the spike in the fragment should be noted. The radiographs taken after five months (*Fig.* 577 G, H) show sound union and recalcification. The patient, who had bilateral fractures (both of which were reduced), returned to full work as a builder, including ladder climbing, after four months.

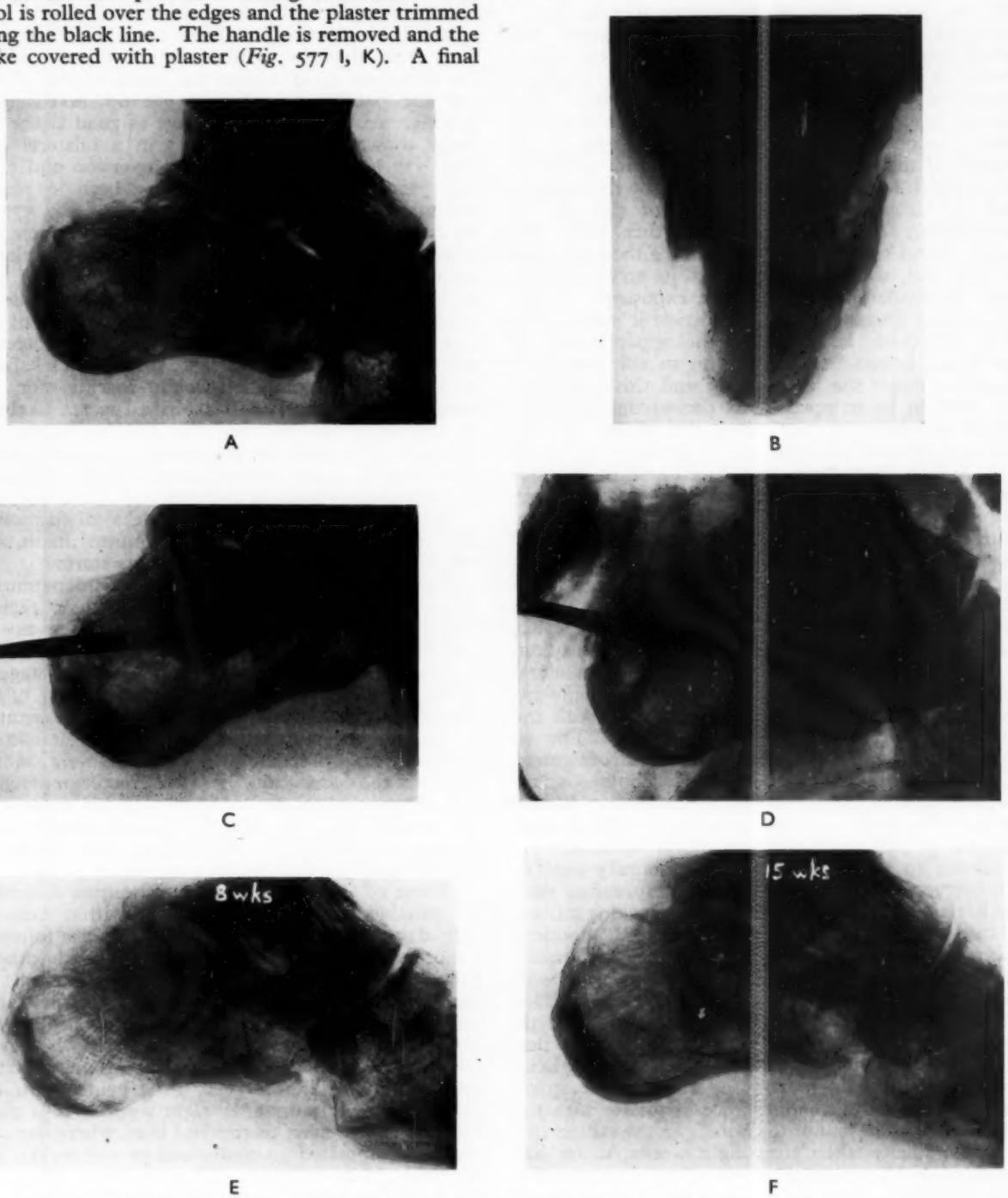



FIG. 579.—Joint depression type of fracture to show stages of reduction. A, B, Initial radiographs; C, Post-reduction appearance with fragments supported by spike; D, Appearance in plaster; E, To show union at eight weeks; F, To show recalcification at fifteen weeks.

**2. Joint Depression Type.**—The principle in this type is to expose the depressed fragment by open operation, to elevate it into alinement under direct vision, and to maintain it by the larger of the Gissane spikes passed through the tuberosity from behind.

In those cases where there is secondary displacement of the tuberosity the spike is used to lever this down into position before the depressed fragment is lifted.

*a. Approach.*—With the patient on his side so that the outer surface of the injured foot is uppermost, an incision is made immediately below the lateral malleolus, running forwards along the upper border of the calcaneus (*Fig.* 578 A). It is deepened above the peroneal tendons towards the sinus tarsi and the upper border of the os calcis in front of the sinus is exposed. The approach leads direct to the capsule of the outer aspect of the posterior subtaloid joint, which has been completely torn by the trauma, and the deeply depressed portion of the joint is immediately exposed. Passing farther back, the middle band of the lateral ligament of the ankle will be seen and, if necessary, a few of its anterior fibres may be divided to improve the exposure. It has never been found necessary to divide it completely. This dissection, keeping near the upper border of the bone, brings the surgeon on to the depressed fragment *inside* the lateral wall, and this wall does not need to be stripped of its periosteum and soft-tissue attachments, nor need the sheath of the peroneal tendons be opened (*Fig.* 578 B).

*b.* A Gissane spike is introduced a short distance into the tuberosity, and if necessary its secondary displacement corrected by traction and angulation. During this procedure the depressed fragment will be seen to move with the tuberosity, but it remains deeply embedded in the cancellous bone, and it becomes quite obvious that no amount of pulling, pounding, force, or manipulation of the os calcis from outside would elevate it into its proper position.

*c.* A bone lever is now passed inside the lateral wall under the anterior end of the depressed fragment, and it is lifted easily into exact alinement with the superior buttress in front (*Fig.* 578 B). The os calcis spike is now worked forward into this fragment to hold the reduction. If there was no secondary displacement of the tuberosity the reduction is now quite stable, but in the severe compressions a small amount of pull on the handle of the spike will be necessary to hold the combined tuberosity-joint in the correct position. Transverse compression with the heels of the palms is applied and a rocking motion to ease home the depressed sustentacular component completes the reduction, which is checked under direct vision once again before the wound is closed.

*d.* The patient can now be turned on to his face or back for the check radiograph, and the shoe-type plaster applied. *Fig.* 579 C is the post-reduction radiograph showing exact alinement of the crucial angle and subtaloid joint, supported by the spike, and *Fig.* 579 D is the appearance in plaster with the spike in the outer half of the bone. In the radiograph of this patient, taken after eight weeks, union has occurred and the normal trabeculation is reappearing (*Fig.* 579 E). The cavity beneath the displaced fragment has filled in completely. At fifteen weeks the radiograph shows that re-calcification of the bone is progressing rapidly, and the patient was allowed to return to work (*Fig.* 579 F).

**After-care.**—The patient is kept in bed with the leg elevated for about ten days. Exercises to the foot, toes, and ankle are started the day following reduction. It has been found that relatively painless ankle movements are possible at once, but it is not until the fourth or fifth day that inversion and eversion become possible in comfort. Swelling has almost disappeared by the end of the first week, but recurs if the patient is allowed up. The pictures show that by the tenth day movements of all the joints are good within the limits of the plaster and the patient can start to get up, non-weight-bearing. At this time it is almost as good as the full range shown after five months in a bilateral case (*Fig.* 577 I, K). The degree of inversion and eversion particularly are worth noting both in plaster and after five months, when it is full (*Fig.* 577 L). He can go home on the fourteenth day and attend for exercises as an out-patient. The spike and plaster are removed in tongue fractures at the end of four weeks, and in joint depression cases a little later—five or six weeks, depending on the severity of the case. My present practice is to apply a protective below-knee plaster at this stage for four weeks, and to keep the patient non-weight-bearing, for the movement that has been established is not likely to be lost, and the fracture may not be sufficiently united to withstand vigorous movement out of plaster. After removal of the spike a shoe-plaster is insufficient to prevent the strains of movement.

At the end of eight to ten weeks all fixation is removed, a radiograph taken to confirm union, and weight-bearing and walking exercises started.

Restoration of the power of the gastrocnemius is of particular importance and the patient rapidly progresses through resisted pulley exercises, tip-toe walking, ladder climbing, and skipping, in this order. In practice quick recovery occurs, and this stage of convalescence depends entirely on the efforts of the patient and the rehabilitation staff. Work is resumed as soon as the surgeon is satisfied that it can be managed, and the date will depend solely on the nature of the occupation. A steel erector or steeplejack requires absolute confidence in his foot, with full power, and may take six months from injury, whereas a labourer on the ground may return to suitable work in three to four months.

**Time of Operation.**—The techniques described are suitable for cases operated on within three to four days of injury. Palmer (1948) has followed Lenormant's technique (Lenormant and others, 1929) and recommends a cancellous bone-graft in the cavity left beneath the depressed fragment after elevation to maintain the reduction. In my experience, if the cases are operated on early, the cavity fills with blood and reforms cancellous bone structure very quickly. There is very little evidence of the cavity on radiography after eight weeks. It is quite reasonable, however, to suppose that, where the case cannot be operated on under one or two weeks, the cavity would be unlikely to fill with clot or new bone. Furthermore, union would be slower, and in cases operated on late there is probably a place for cancellous graft. This requires a more extensive local exposure, and the achievement of a stable exact reduction by this means is technically more difficult.

## RESULTS (*Tables III, IV*)

From the literature the *number* of patients with permanent disability varies between 13 and 25 per

*Table III.*—Os Calcis Fractures: Numbers of Cases

| | Total No. of Cases 173 | Return to Work (In Months) | | | | | Time for Recovery to Stable Symptomatology (In Months) | | | | | | Residual Symptoms | | | | | | | Examination | | | | Radiograph at Follow-up | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Within: 3 | 6 | 12 | Did not return | Not known | 3 | Within: 6 | 9 | 18 | Over 19 | Not known | Nil | Trivial | Nil and trivial, i.e., 'good' | Disabling for recreation | Disabling for work | Severe | Not known | Normal foot | Limitation of movement | Stiff foot | Not known | Normal | New architecture | Deformed | Not known |
| Overall results | | 32 | 74 | 43 | 16 | 10 | 22 | 44 | 34 | 42 | 20 | 13 | 53 | 58 | 26 | 26 | 24 | 8 | 6 | 63 | 73 | 28 | 11 | 47 | 65 | 28 | — |
| Fractures without displacement:— | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 34 | 10 | 15 | 7 | 2 | — | 8 | 13 | 3 | 4 | 4 | 2 | 18 | 9 | 27 | 3 | 2 | — | 2 | 24 | 5 | 1 | 4 | 20 | 4 | — | 10 |
| Treated in plaster | 14 | 5 | 3 | 4 | 2 | — | 5 | 4 | 1 | 2 | 1 | 1 | 7 | 3 | 10 | 2 | 1 | — | 1 | 10 | 2 | 1 | 1 | 7 | 2 | — | 5 |
| Treated by exercises | 20 | 5 | 12 | 3 | — | — | 3 | 9 | 2 | 2 | 3 | 1 | 11 | 6 | 17 | 1 | 1 | — | 1 | 14 | 3 | — | 3 | 13 | 2 | — | 5 |
| Under age of 50 | 24 | 7 | 12 | 5 | — | — | 5 | 12 | 1 | 1 | 4 | 1 | 14 | 7 | 21 | 3 | — | — | — | — | — | — | — | — | — | — | — |
| Over age of 50 | 10 | 3 | 3 | 2 | 2 | — | 3 | 1 | 2 | 3 | — | 1 | 4 | 2 | 6 | — | 2 | — | 2 | — | — | — | — | — | — | — | — |
| Fractures with displacement:— | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Not reduced: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 65 | 10 | 29 | 13 | — | 13 | 4 | 13 | 18 | 17 | 10 | 3 | 15 | 26 | 41 | 11 | 7 | 6 | — | — | — | — | — | — | — | — | — |
| Under age of 50 | 35 | 5 | 16 | 8 | — | 6 | 4 | 7 | 3 | 10 | 7 | 4 | 7 | 14 | 21 | 9 | 3 | 2 | — | — | — | — | — | — | — | — | — |
| Over age of 50 | 30 | 5 | 13 | 5 | — | 7 | — | 6 | 14 | 7 | 3 | — | 8 | 12 | 20 | 2 | 4 | 4 | — | — | — | — | — | — | — | — | — |
| Reduction series:— | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 80 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Successful: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 38 | 9 | 18 | 4 | — | 7 | 8 | 13 | 7 | 4 | 3 | 3 | 15 | 15 | 30 | 5 | 2 | 1 | — | — | — | — | — | — | — | — | — |
| Over age of 50 | 14 | — | 4 | 6 | — | 4 | 2 | 1 | 2 | 4 | 3 | 2 | 3 | 3 | 6 | 3 | 4 | — | 1 | — | — | — | — | — | — | — | — |
| Unsuccessful: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 18 | 1 | 8 | 7 | — | 2 | 1 | 2 | 3 | 6 | 1 | 5 | 2 | 1 | 3 | 3 | 5 | — | 7 | — | — | — | — | — | — | — | — |
| Over age of 50 | 10 | — | 1 | 6 | — | 3 | — | 2 | 1 | 5 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | 1 | 1 | — | — | — | — | — | — | — | — |
| Tongue fractures by spike | 39 | 8 | 15 | 8 | 3 | 5 | 10 | 7 | 5 | 8 | 3 | 6 | 9 | 12 | 21 | 6 | 7 | 1 | 4 | 10 | 20 | 5 | 4 | 12 | 16 | 1 | 10 |
| Joint depression fractures by open reduction | 35 | 2 | 17 | 13 | 1 | 2 | — | 12 | 7 | 10 | 2 | 4 | 10 | 9 | 19 | 6 | 6 | 1 | 3 | 9 | 17 | 6 | 3 | 7 | 16 | — | 10 |
| Treated by plaster only | 33 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 20 | 2 | 10 | 3 | — | 5 | 2 | 3 | 5 | 4 | 5 | 1 | 4 | 6 | 10 | 7 | 1 | 2 | — | — | — | — | — | — | — | — | — |
| Over age of 50 | 13 | 2 | 3 | 5 | — | 3 | 1 | 4 | 2 | 3 | — | 3 | 3 | 3 | 6 | 1 | 2 | — | 4 | — | — | — | — | — | — | — | — |
| Treated by exercise only | 52 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 24 | 9 | 7 | 4 | 2 | 2 | 5 | 7 | 4 | 5 | 2 | 1 | 10 | 11 | 21 | 1 | 2 | — | — | — | — | — | — | — | — | — | — |
| Over age of 50 | 28 | 3 | 13 | 3 | 5 | 4 | — | 8 | 8 | 7 | 3 | 2 | 7 | 11 | 18 | 1 | 3 | 4 | 2 | — | — | — | — | — | — | — | — |

*Table IV.*—Os Calcis Fractures: Percentage of Known Cases

| | Return to Work (In Months) | | | | Time for Recovery to Stable Symptomatology (In Months) | | | | Residual Symptoms | | | | | | Examination | | | Radiograph at Follow-up | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Within: 3 | 6 | 12 | Did not return | Within: 3 | 6 | 9 | 18 | Nil | Trivial | Nil and trivial, i.e., 'good' | Disabling for recreation | Disabling for work | Severe | Normal foot | Limitation of movement | Stiff foot | Normal | New architecture | Deformed |
| Overall results | 19·4 | 64·3 | 90·4 | 9·7 | 13·6 | 40·7 | 61·6 | 87·5 | 31·4 | 34·3 | 65·7 | 15·4 | 14·2 | 4·7 | 38·4 | 44·5 | 17 | 33·6 | 46·4 | 20 |
| Fractures without displacement:— | | | | | | | | | | | | | | | | | | | | |
| Total | 29 | 74 | 94 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Treated in plaster | 36 | 57 | 86 | — | 38 | 69 | 77 | 92 | 54 | 23 | 77 | 15 | 7 | — | 77 | 15 | 7 | 78 | 22 | — |
| Treated by exercises | 25 | 85 | — | — | 16 | 47 | 74 | 84 | 58 | 32 | 90 | 5 | 5 | — | 82 | 18 | — | 87 | 13 | — |
| Under age of 50 | 29 | 79 | 93 | — | 22 | 76 | 80 | 84 | 61 | 30 | 91 | 9 | — | — | — | — | — | — | — | — |
| Over age of 50 | 30 | 60 | 80 | — | 33 | 44 | 66 | — | 50 | 25 | 75 | — | 25 | — | — | — | — | — | — | — |
| Fractures with displacement:— | | | | | | | | | | | | | | | | | | | | |
| Not reduced: | | | | | | | | | | | | | | | | | | | | |
| Total | 17 | 66 | 88 | — | 6 | 29 | 58 | 85 | 23 | 40 | 63 | 17 | 11 | 9 | — | — | — | — | — | — |
| Under age of 50 | 16 | 65 | 90 | — | 14 | 36 | 46 | 81 | 20 | 40 | 60 | 27 | 9 | 6 | — | — | — | — | — | — |
| Over age of 50 | 17 | 66 | 83 | — | — | 19 | 67 | 89 | 26 | 40 | 66 | 7 | 13 | 13 | — | — | — | — | — | — |
| Reduction series:— | | | | | | | | | | | | | | | | | | | | |
| Successful: | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 29 | 87 | — | — | 23 | 60 | 80 | 91 | 40 | 40 | 80 | 13 | 5 | 2 | — | — | — | — | — | — |
| Over age of 50 | — | 40 | 60 | — | 17 | 25 | 42 | 76 | 22 | 22 | 44 | 22 | 34 | — | — | — | — | — | — | — |
| Unsuccessful: | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 6 | 50 | — | — | 8 | 23 | 46 | 92 | 18 | 9 | 27 | 27 | 45 | — | — | — | — | — | — | — |
| Over age of 50 | — | 17 | 83 | — | — | 22 | 33 | 89 | 11 | 22 | 33 | 34 | 22 | 1 | — | — | — | — | — | — |
| Tongue fractures by spike | 24 | 68 | 91 | 9 | 30 | 51 | 67 | 91 | 26 | 34 | 60 | 17 | 20 | 3 | 29 | 57 | 14 | 41 | 55 | 4 |
| Joint depression fractures by open reduction | 6 | 57 | 97 | 3 | 39 | 62 | 94 | 6 | 31 | 28 | 59 | 19 | 19 | 3 | 28 | 53 | 19 | 28 | 64 | — |
| Treated by plaster only: | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 10 | 60 | 75 | 25 | 11 | 17 | 53 | 74 | 20 | 30 | 50 | 35 | 5 | 10 | — | — | — | — | — | — |
| Over age of 50 | 15 | 38 | 76 | — | 10 | 50 | 70 | — | 33 | 33 | 66 | 11 | 22 | — | — | — | — | — | — | — |
| Treated by exercise only: | | | | | | | | | | | | | | | | | | | | |
| Under age of 50 | 39 | 69 | 86 | 9 | 22 | 52 | 69 | 92 | 42 | 46 | 88 | 4 | 8 | — | — | — | — | — | — | — |
| Over age of 50 | 12 | 66 | 79 | — | — | 29 | 58 | 83 | 27 | 42 | 69 | 4 | 11 | 15 | — | — | — | — | — | — |

cent of those injured. Olovson gives complete recoveries in six months as 50 per cent and in six years 75 per cent, and this agrees with other writers. The average *degree* of permanent disability recorded varies between 12 and 75 per cent for all cases, with an average about 20 per cent (Eastwood, 1938; Forrester, 1916; Hermann, 1930; Hosford, 1936; Jaekle and Clark, 1937; Magnuson, 1923; Malpas, 1927; Page and Mumford, 1945; and others).

From the industrial point of view, McFarland (1937) found that occupation was important, for whereas 50 per cent of labourers were permanently disabled, the figure rose to 80 per cent for stevedores and coal-heavers, but was only 10 per cent for painters and housewives.

The slow improvement continuing over three to six years stressed by G. E. Wilson (1950), Olovson (1940), and Mercer (1944) needs examination, and an endeavour has been made to assess the time of recovery to a stable condition in each case followed up. Sayle Creer, who has kindly given me permission to quote figures he reported to the British Orthopædic Association in 1946, showed that after three years 80 per cent of cases had returned to full work, but the remaining 20 per cent were still incapacitated at the end of seven years (*Table V*). In the series reported here the proportion of patients complaining of severe symptoms after an eighteen-month interval was the same as that in the group seen four or more years after injury. In other words, 90 per cent of the patients were found to be stabilized or had ceased to improve by the eighteenth month, and where severe symptoms persisted beyond this time they appeared to be permanent. The cause of persistent pain is not finally agreed, but whether it is due to traumatic arthritis, avascular necrosis, deformity of the foot, capsular fibrosis, or a combination, this cause is present from the beginning, for in no case was early improvement followed by an increase in pain, at least after a latent period up to eight years. I am in no doubt that union in deformity, with the concomitant scar formation in the torn soft tissues, is the primary cause of the persistent symptoms and does delay recovery. Where, for example, a new architecture according to Wolff's

*Table V.*—Crush Fractures—Return to Work
(70 patients followed up. Reported by Mr. Sayle Creer in 1946.)

| Period (yr.) | ½ | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Percentage of Total at light work | 21 | 19 | 22 | 20 | 23 | 22 | 22 | 21 |
| Percentage of Total at full work | 31 | 59 | 71 | 78 | 77 | 78 | 78 | 79 |
| 'Round' figures (statistically significant) Per cent | 30 | 60 | 70 | 80 | 80 | 80 | 80 | 80 |

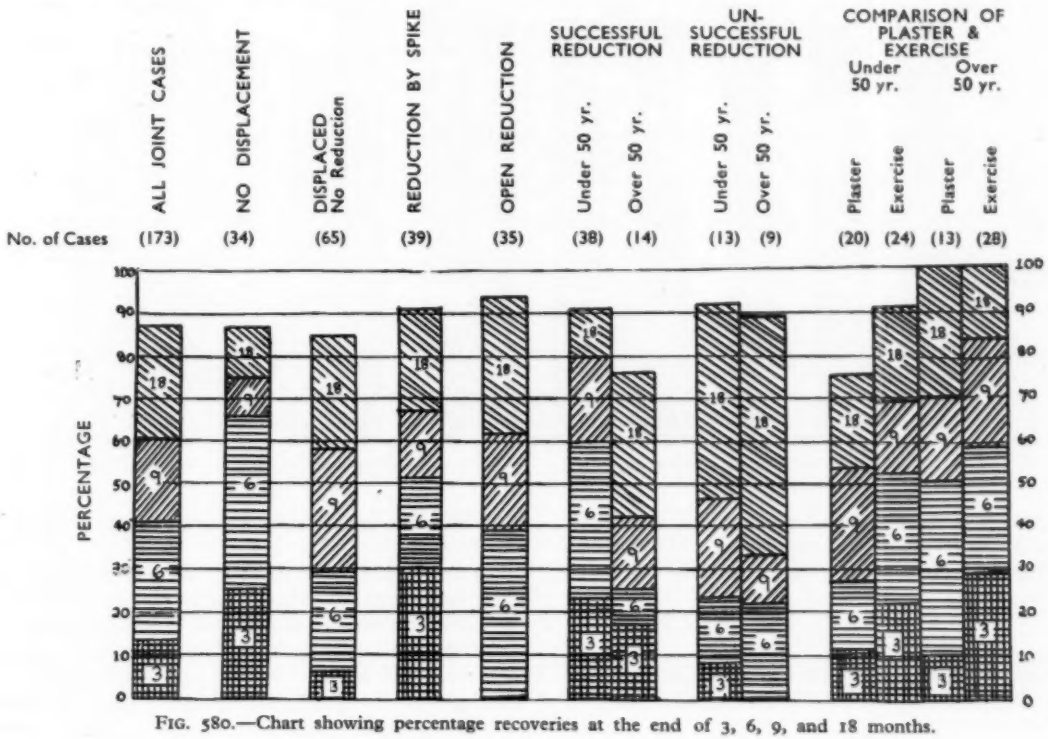



Fig. 580.—Chart showing percentage recoveries at the end of 3, 6, 9, and 18 months.

*Table VI.*—New Architecture and Recovery Time

| | 'Normal' Radiograph | | New Architecture and Deformed | |
|---|---|---|---|---|
| | No. | Percentage | No. | Percentage |
| Time for recovery: | | | | |
| under 3 months | 6 | 17 | 4 | 5 |
| under 6 months | 14 | 57 | 18 | 27 |
| under 9 months | 2 | 63 | 19 | 51 |
| under 18 months | 7 | 83 | 27 | 85 |
| over 19 months | 6 | 17 | 12 | 15 |

laws (1896) was developed, there was considerable delay in recovery to stability compared with the fractures uniting without deformity. Furthermore, in the light of the recent work on the mechanics of locomotion from the University of California (1947), in which it was shown that over half of the normal 20° rotation of the tibia in walking is absorbed by the subtaloid joints, a painful periarticular fibrosis in this region can be a real disability. Of the 25 cases with stiff feet in our series 15 were disabled for work.

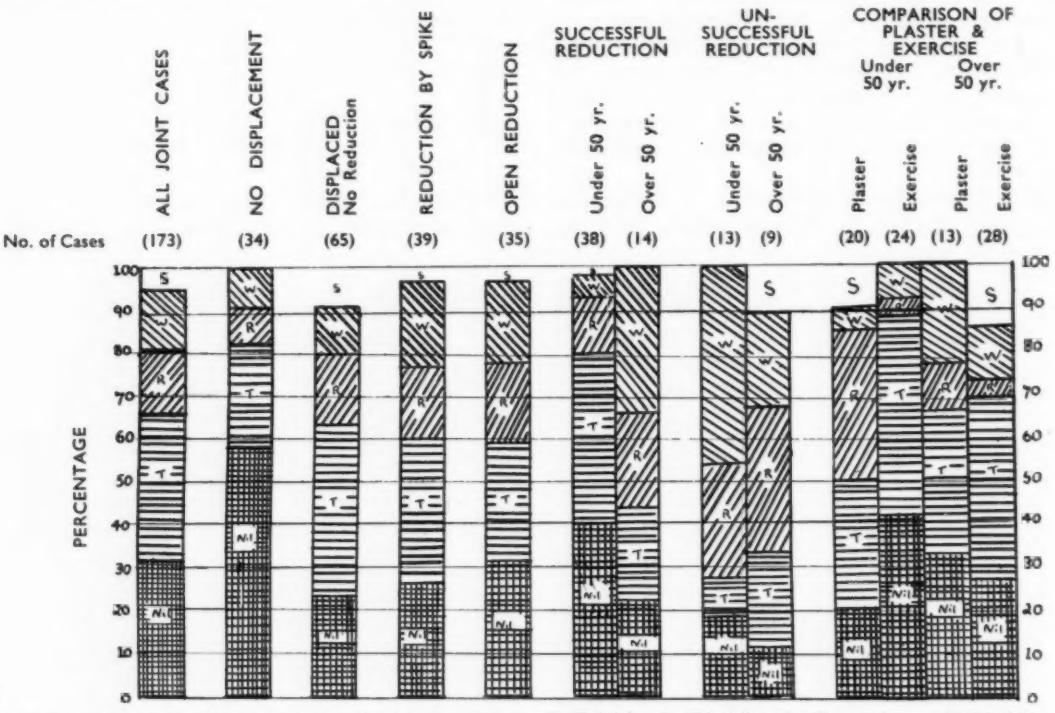



FIG. 581.—Chart showing percentage of residual symptoms. T, Trivial; R, Disabling for Recreation; W, Disabling for Work; S, Severe.

## PRESENT SERIES

The present series of 173 cases with joint involvement has been analysed to contrast the various methods of treatment, and to present the results under three main headings: (1) The time in the patient's estimation during which significant improvement continued to take place, i.e., the time of recovery to stability, after which the residual symptoms were permanent; (2) The time off work; (3) The residual symptoms.

In considering the findings it should be made clear that almost throughout the period under review the fracture has been treated very seriously and from April, 1942, most cases in which the displacement was judged to be amenable to reduction were reduced. During this time the present treatment has evolved and the failures of early experiment have been included in the reduction series. At the same time the cases not reduced have been to a large extent selected by exclusion, and the results of their treatment are probably better than in a completely unselected series. Thus the differences between the recorded results over the whole period are less dramatic than the various methods deserve. The results of reduction to-day are considerably in advance of other methods in the right cases and its use is justified in all fractures with more than minimal displacement in patients under the age of 50. In each of the three charts the patients are grouped according to treatment and divided into those under 50 and over 50. The cases reduced are subdivided into those which were successful and those which were not.

The chart shown in *Fig.* 580 gives in each column the percentage of patients who recovered to a stable, permanent symptomatology in various times: three, six, nine, and eighteen months. In each patient the time was his estimation of the interval after injury during which significant improvement continued to take place, and after which any residual symptoms become permanent.

*Fig.* 581 shows the percentage of patients complaining of no symptoms, trivial symptoms, disability for recreation or work (even though he might be back at work), and severe disability. The degree of disability was gauged on my assessment of the statements made by the patient and his subjective response to examination, and for practical purposes those without any symptoms and those with trivial complaints can be classed together as good results.

*Fig.* 582 shows the percentage who returned to work in under three, six, or twelve months.

**Significant Findings.—**

1. *All Cases.*—88 per cent had recovered to their final condition in eighteen months, 65 per cent had good results, 5 per cent were left with severe disability, and 91 per cent had returned to work in under one year. These overall results are better than one had been led to expect from the literature.

2. *Cases without Displacement.*—These may be regarded as a key series, which should give the best results, for displacement has never occurred. Over four-fifths had good results, and 95 per cent returned to work under one year.

3. *The Unreduced.*—Those with displacement which were not reduced are, in the main, those left after the cases for reduction have been selected; 9 per cent have severe symptoms and 65 per cent returned to work under six months. The results are similar to the general average for all cases, and suggests that the selection has been well done.

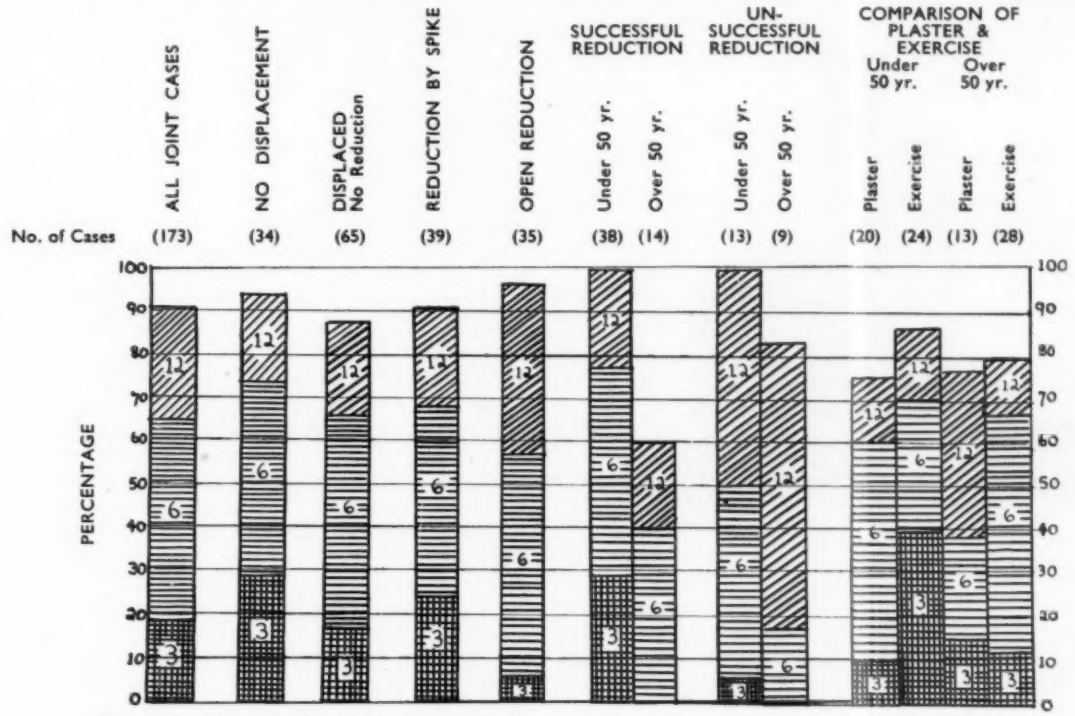



FIG. 582.—Chart showing the percentage who returned to work at the end of 3, 6, and 12 months.

4. *The Operated Cases.*—The results of cases reduced by spike or open operation did not at first appear to show much improvement over the general average, but when they were subdivided into the successful and unsuccessful reductions, and into the under and over fifties, the reason at once became obvious.

*a. Successful Reduction under* 50: The 'round' figure to remember is 80: 80 per cent stabilized under nine months, 80 per cent with none or trivial symptoms, and 80 per cent back at work under six months. All had returned to work under one year. In general they are quite as good as those never displaced and very much better than those not reduced.

*b. Successful Reduction over* 50: Even though successful, operation over 50 gives poor results. The figure to remember is 40: 40 per cent stabilized under nine months, 40 per cent with trivial symptoms, and 40 per cent back at work under six months.

*c. Unsuccessful Reduction*: Now the figure is 20 per cent, for stability under *six* months and return to work over 50 in this time; 70 per cent are disabled for work or play at all ages, and all the severe cases except one are in the unsuccessfully reduced group over 50. These findings may explain much of the gloom in the literature, and why so many of the incomplete methods of reduction by pounding, pulling, and hammering have fallen into disrepute.

5. *Plaster v. Exercise.*—Exercise therapy has the advantage of plaster at all ages. Over 50 exercise is much better than successful or unsuccessful reduction. Under 50 it is not as good as successful reduction.

## CONCLUSIONS ON TREATMENT

Summing up these findings as conclusions:—

1. Exercise therapy is the best treatment for displaced fractures in patients over the age of 50, and, of course, in all without displacement.

2. Successful reduction enables all to return to work under one year, and gives the best results of any treatment under the age of 50.

3. Operation over the age of 50 is definitely contra-indicated if it has to be followed by immobilization, as these cases were, but the shoe-plaster technique may enable older patients to be treated with success. The oldest patient I have used it for so far is aged 79.

4. Unsuccessful or incomplete reduction gives the worst results here as elsewhere in the body, and anything short of exact post-operative alinement has been regarded as unsuccessful. In view of this, it is most strongly recommended that where an exact reduction cannot be achieved on the operating table the method should be abandoned, for in such circumstances exercise alone will give a better result.

5. *Shoe-plaster Cases.* To this analysis I would like to add a brief word on those 7 successful reductions treated in shoe plasters with immediate exercise the results of which are available : one was stabilized without symptoms and was back at work in nine weeks, 5 more were stabilized in under six months, and the last in under nine months ; and all were back at work in under six months ; 4 have no symptoms, 2 have trivial symptoms, and 1 is disabled for football. One patient with a bilateral fracture was back at full work in comfort as a steeplejack in four months.

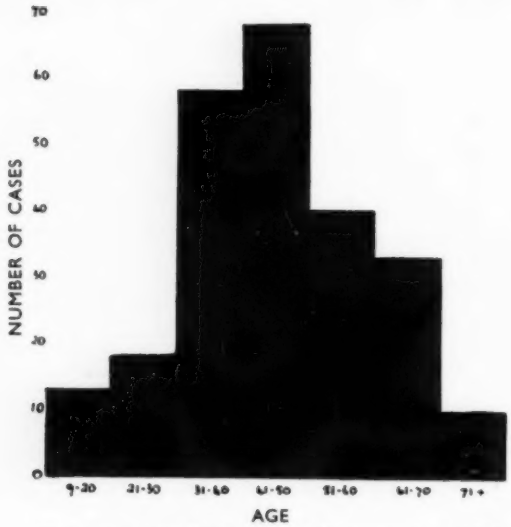


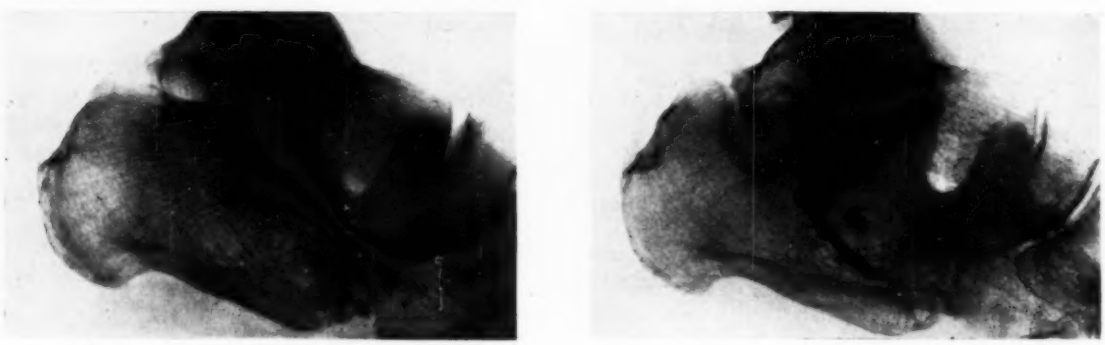

FIG. 583.—Age distribution of fractures of os calcis (241 cases).

**Age Distribution** (*Fig.* 583).—The greatest number of os calcis fractures occur between the ages of 31 and 50, and 69 per cent between 41 and 60 ; 65 per cent are under 50 years of age, and 35 per cent over this age. A high proportion occur, therefore, at an age when reduction offers a chance of good recovery.

**Association with Spine Fractures.**—Schofield (1936) reported that 12 per cent, and Hermann (1937) that 10 per cent, of os calcis fractures are associated with anterior wedge fractures of the vertebral column. The mechanism of production is similar and the relationship is not only one to be expected, but looked for in every case. In this series 5 cases had vertebral fractures—2 at L.1, 2 at L.2, and 1 at L.3—3 per cent.

**The Place of Arthrodesis.**—The high proportion of painful heels and severe disability reported by many surgeons has led some to recommend early arthrodesis, but the results of this have not been as good as was hoped. Philip Wilson (1938) reported 24 good, 6 fair, and 3 poor results in 40 subtaloid arthrodeses out of 59 cases of fractured os calcis, but G. E. Wilson (1950) advises long delay before operating because " Nature is a wonderful healer if given sufficient time ". Conn (1935) condemned subtaloid arthrodesis in favour of triple fusions because the subtaloid and mid-tarsal joints function as one unit and " simple, subastragaloid arthrodesis failed to yield satisfactory feet in at least one-third of the fresh and in one-half of the late lesions ". Both Conn and Philip Wilson agree that late arthrodesis is a difficult technical procedure, because of the need to correct the deformity if the operation is to be successful. Simon and Stultz (1930) argue against immediate arthrodesis on the grounds that reduction is easy, and arthrodesis without reduction must be in deformity. There were only 2 patients in the whole series who welcomed triple arthrodesis when followed up after four years. These two had completely stiff, valgoid, and painful feet, with tenderness over all the joints and the outer side of the os calcis, and were considerably relieved by fusion.

**Unusual Fracture of Body of Os Calcis with Forward Dislocation.**—There were 6 examples of the unusual type of fracture of the body associated with forward dislocation at the subtaloid joint, shown in *Fig.* 584. All had been treated without reduction and 2 had troublesome symptoms. The second radiograph was taken after four and a half years in a case without any symptoms, but with a completely stiff subtaloid joint.



A B

FIG. 584.—A, Fracture of body of os calcis with forward dislocation of subtaloid oint ; B, After a further four years.

**Complete Excision of the Os Calcis.**—Reference should be made to treatment by complete excision of the grossly comminuted fracture, often compound, first advocated by Lériche (1913) and recently by Pridie (1946). It is very rarely necessary and only 1 such case has been done in this series : the patient was walking reasonably well after eight months.

## CONCLUSIONS

It has been the purpose of this paper to show that there are two very constant patterns of crush fractures of the calcaneus, and in this respect it confirms the recent work of Palmer. Each of these two types of fracture when displaced can be reduced exactly by simple methods.

Of all fractures of the calcaneus, however, 50 per cent either do not involve the posterior subtaloid joint or show no displacement of it, and only 4 per cent are so smashed that reduction is impossible. Thus over half the cases have displaced fractures which can be reduced, but it has been found that over the age of 50 exercise therapy produces better results. Those with displacement over the age of 50 form 20 per cent of the total, so that over 60 per cent of all cases are best treated by exercises alone.

In the remaining 35–40 per cent, the patient is under the age of 50 and has a displaced fracture of the calcaneus. If union is allowed to occur in deformity the patient's return to work is delayed and he is often left with permanent disability. It is for this group that reduction by one of the two techniques described is urged, for experience has shown that normal pre-accident mobility in a pain-free foot can be expected, with a return to full work within six months.

Careful follow-up shows clearly that the bad results of reduction arise from incomplete reduction, and that an exact reposition of the fragments is essential. Where, at operation, this cannot for some reason be done, the method should be abandoned and the patient treated by exercise alone. It is submitted that with the methods suggested in this paper an exact reduction can be achieved with ease in the great majority of cases.

I would like to acknowledge with gratitude the help and stimulus of Mr. William Gissane, in allowing me to take over the practice of a technique in which he had made so many advances, and established the principles. I thank him and my colleagues for permitting me to report their results along with my own, and for giving me all their patients to treat during the last three years. My thanks are due to Mr. N. R. Gill and Mr. C. R. Richardson, of the Photographic Department of the Birmingham Accident Hospital, for the illustrations.

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# TUBERCULOUS DISEASE OF THE BREAST

By K. C. McKEOWN and K. W. WILKINSON

DEPARTMENT OF SURGERY, POST-GRADUATE MEDICAL SCHOOL OF LONDON, HAMMERSMITH HOSPITAL

THE mammary gland is an infrequent site of tuberculous disease. The earliest description of the condition was that of Sir Astley Cooper who, in 1829, recorded the occurrence of " scrofulous swellings in the bosom " of young women suffering from enlargement of the cervical glands. Since that time case records and surveys of the literature have been published at infrequent intervals (Nélaton, 1839; Cuneo, 1868). In more recent years Shipley and Spencer (1926) were able to report 205 cases, while Morgen (1931), in a most comprehensive review of the literature, was able to collect 439 cases. Five cases treated recently, two of them with streptomycin, perhaps justify a reconsideration of the disease.

**Incidence.**—The incidence of tuberculous mastitis, though certainly not high, is frequent enough to merit attention. The importance of its study is emphasized by the difficulty that is experienced in differentiating between this disease and carcinoma of the breast—a difficulty which is very apparent from a study of the recorded cases.

An indication of the frequency of this disease is shown by the figures of the Mayo Clinic, where between the years 1904 and 1915, 6 cases of tuberculous mastitis were reported, representing 0·51 per cent of all mammary conditions under treatment. At St. Bartholomew's Hospital, London, of 1,500 cases admitted with breast lesions 1·5 per cent proved tuberculous (W. E. B. Hall, 1936). That the condition is not especially associated with the graver types of tuberculosis is shown by the figures of Raw (1924), who in thirty years' experience in a sanatorium was able to record only 7 cases. In the breast clinic at the Post-Graduate Medical School of London during the past eighteen months, 4 cases of the disease have been treated, and these cases are recorded in this paper together with another recent case of one of the authors (K. C. McK.).

*Age.*—The majority of cases occur between the ages of 20 and 50 years, especially in the earlier periods of this age grouping. The extremes of life are, however, by no means immune, and a case has been recorded in a male infant of six months, and another in an elderly woman of 73 (Charache, 1934).

*Sex.*—The disease occurs almost exclusively in females, and in his series of 439 cases, Morgen records only 20 occurring in men, an incidence of 4·5 per cent. The first case of tuberculous mastitis affecting the male is said to be that recorded by Heyfelder just a century ago.

**Heredity.**—A family history of tuberculosis was obtained, according to Barker (1926), in only 13 per cent of the cases. In patients in whom mastitis was the presenting manifestation of tubercle, the so-called ' primary ' type, the previous history was found to be clear, the family history above suspicion, and the patient's general health remarkably good. This certainly was not true of the ' secondary ' type, where the breast condition merely represented yet another threat to the survival of a patient already in jeopardy from long-standing infection in some other site or sites.

**Lactation.**—The relationship of the condition to lactation is quite established, its occurrence being much more common in women who have borne children (Webster, 1939).

**Association with Cancer of Breast.**—The clinical similarity between certain types of breast tubercle and mammary carcinoma has been mentioned in an earlier paragraph, but not infrequently the two conditions coexist. Grausman and Goldman, quoted by Raven (1949), collected 28 such cases. If such an association is more than coincidental, the relationship between the two lesions is not clearly understood, as either lesion may take precedence, or the conditions may develop synchronously. It may be that the neoplastic area is one of diminished resistance to infection, with consequent establishment of a tuberculous focus, or alternatively the chronic irritation of the tuberculous lesion may have initiated the neoplastic process. Since, however, the lesions may occur in anatomically discrete sites, it may well be that no real relationship exists, but rather that the apparent association of the two conditions is due to an eagerness to report such striking cases of double pathology.

**Route of Infection.**—The breast may become infected in a variety of ways, and there is no general agreement as to which is the usual route of infection.

1. *Hæmatogenous Spread.*—The occurrence of mastitis as the only clinical manifestation of tuberculous infection has led observers to assume that the organism has gained entry to the mammary tissue by the blood-stream. Such a route would explain the occurrence of the ' primary ' type of tuberculous mastitis. That such a route of infection is frequent, is, however, subject to doubt. Nagashima (1925) performed 34 autopsies in cases of miliary tubercle, but in none of these was able to demonstrate tuberculous lesions in the breast; while Raw (1924) in 10,000 autopsies in a sanatorium found tuberculous mastitis in only 7 cases. It would seem that the breast is resistant to tuberculous infection by the blood-stream, even in patients debilitated by the disease.

2. *Direct Inoculation.*—This route is distinctly rare, though Ely (1890) has recorded a case in which the disease was thought to have followed direct contact with linen infected with tuberculous sputum.

3. *Ductal Infection.*—Infection spreading along the lactiferous channels has been recorded, and cases have been described in which the tuberculous lesions have been located along the ducts, while the interacinous tissue has remained completely free.

4. *Spread from Contiguous Structures.*—This may be regarded as a frequent route of infection, and in two out of three cases recorded by Hall (1936), infection reached the breast by direct spread from the underlying chest wall. The deep focus may be in a rib, in the sternum, or in the shoulder-joint, but most frequently it is located in the costochondral junction, as a recent paper has shown (Raven, 1949).

5. *Lymphatic Spread.*—It is probable that lymphatic routes are the more usual ways by which the mammary gland becomes infected with tuberculosis.

Of Raw's (1924) 7 cases of tuberculous mastitis occurring in patients under treatment in a sanatorium, 3 were males and 4 were females. All four of the women and one man gave a history of cervical

Spread of infection from intrathoracic foci to the breast via the lymphatics must seriously be considered. A focus in the tracheobronchial glands spreads and involves the more central paratracheal group. By a process of retrograde spread similar to that already noted, the internal mammary lymph-glands (sternal lymph-glands) may become

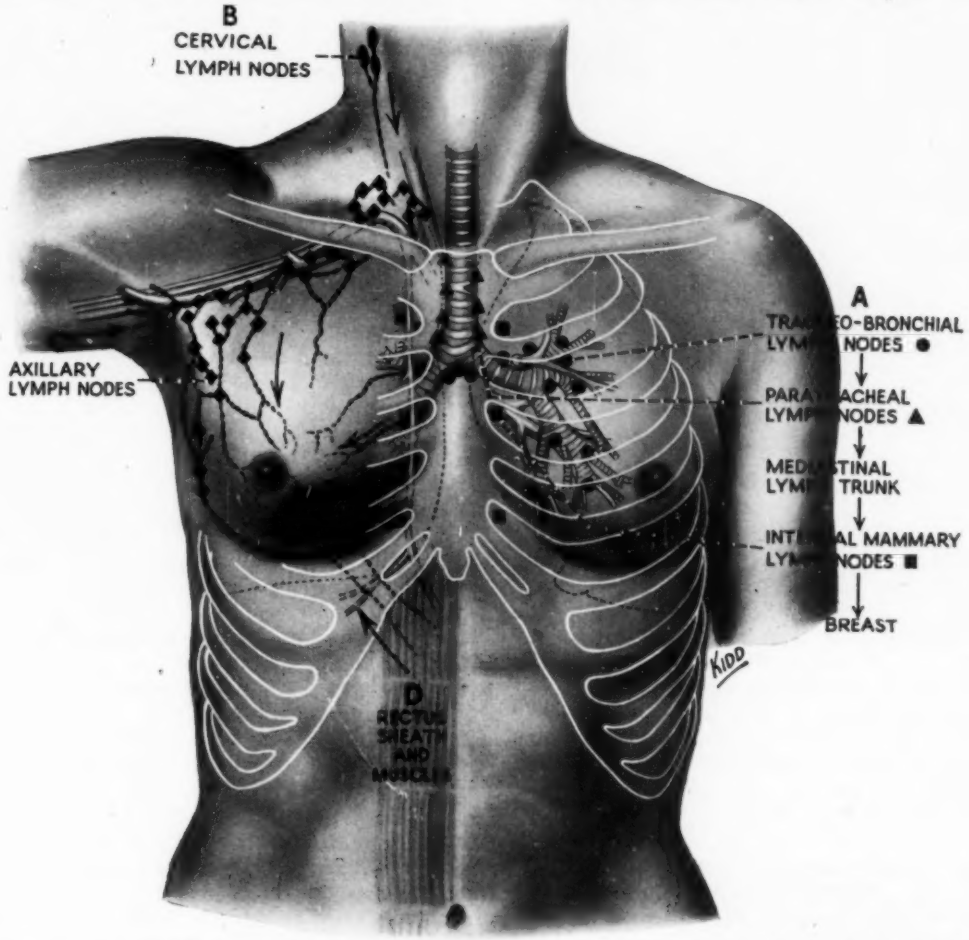


FIG. 585.—A, Shows route of infection from lungs to tracheobronchial lymph-nodes, through the paratracheal nodes to the internal mammary nodes, and from there to the subareolar plexus of Sappey in the breast. B, C, Show routes of spread from a brachial or cervical focus via the axillary lymph-nodes to the breast. D, Route of spread from the rectus sheath.

glandular tubercle, followed later by extension to the axillary glands and finally to the breast.

Deaver (1914) quotes the remarkable case of a patient who sustained a laceration of the finger while washing linen infected with tuberculous sputum. The wound became septic and eight months later the patient developed an axillary abscess on the same side, which failed to heal after drainage. Three months later a swelling developed in the related breast, which proved to be a tuberculous breast abscess.

It is interesting to note in these cases cited by Raw and Deaver that the axillary glands were involved by the disease before the breast became affected. This clinical feature has been observed by various authors in from 56 to 75 per cent of cases. Presumably the extension from the axillary lymph-glands to the breast is by retrograde spread along the lymphatics.

affected and finally the breast is infected (route A in *Fig.* 585). It would appear that the method of spread from an intrathoracic focus to the breast is in exactly the reverse direction to the route by which carcinoma of the breast may metastasize to the lungs. *Fig.* 585 also shows the possible routes, B and C, of lymphatic spread, from a brachial or cervical focus to the axillary lymph-nodes and then to the breast, while D indicates the route of spread from an intra-abdominal focus by way of rectus sheath to the breast.

**Pathology.**—The mammary lesion may present as the only manifestation of tuberculosis in a patient otherwise in good health, where the primary focus remains obscure and there has been no previous history of active tuberculous infection. This condition is referred to as 'primary' mammary tuberculosis and is in marked contrast with the secondary type where the patient has had a long-standing

history of infection and presents with active tuberculosis usually affecting the adjacent tissues.

The disease is usually unilateral, and the sides are affected with equal frequency. Of 399 cases quoted by Lee and Floyd (1934) only 13 were bilateral.

The disease produces a variety of lesions in the breast, which may be classified as follows :—

*a. Acute Miliary Tuberculous Mastitis*, where the mammary lesion infrequently presents as a manifestation of generalized miliary spread, is of little clinical significance.

*b. Nodular Tuberculous Mastitis.*—This is the commonest type of the disease, and primarily affects the supporting tissue of the breast. The lesion spreads slowly over a period of months, and forms a typical caseous lesion which becomes fixed to surrounding structures and ultimately forms a chronic discharging sinus.

*c. Disseminated Tuberculous Mastitis* results from the formation of multiple tubercles over a wide area of breast tissue which caseate and form multiple discharging sinuses.

*d. Sclerosing Tuberculous Mastitis* occurs more commonly in older women. The progress of the condition is conspicuously slow and sinus formation does not occur. Caseation is limited to a few scattered foci in dense fibrous tissue. The breast shrivels and the nipple becomes retracted. It is this type of tuberculosis which presents such striking similarities to carcinoma, both in its clinical appearance and age incidence. So remarkable is the resemblance that on several occasions the breast has been excised for carcinoma, the true nature of the lesion only being discovered on microscopy.

*e. Tuberculous Mastitis Obliterans* apparently arises from infection spreading along the mammary ducts. There is marked epithelial proliferation in the ducts, followed by necrosis and periductal fibrosis, which lead to obliteration of the lumen.

Atypical types occur and the association with carcinoma has already been mentioned.

The infecting organism is most commonly of the bovine type, and considerable difficulty may be experienced in demonstrating the bacillus.

**Symptomatology.**—In the 'secondary' type, the long history of tuberculosis will lead the clinician to suspect the nature of the breast lesion. The association of tuberculous mastitis with lesions of a similar nature in the costal cartilage, sternum, and shoulder-joint are frequent, while the disease occurring in association with cervical and axillary lymphadenitis has been illustrated, particularly by the clinical histories recorded by Raw (1924).

Primary tuberculous mastitis is a condition much more difficult to diagnose, since it occurs in healthy patients and with no previous history of tubercle. The local clinical appearance varies with the type of pathological lesion present, and is frequently mistaken for some other disease.

The first symptom in two-thirds of the patients is a swelling in the breast which increases in size and becomes fixed to skin. Pain occurs as the swelling begins to gain its adherence to skin, but is not a marked feature in the earlier stages of disease. Axillary gland enlargement is present in 50 per cent of the cases, and may precede the development of the breast swelling. The disease progresses over a period of several months and finally an obvious abscess develops, which discharges or is incised, and forms a sinus which persists and discharges a thin watery pus. More rarely the disease takes a more acute course and closely resembles an acute pyogenic abscess.

In the sclerosing type of mastitis the breast becomes hard, fixed to skin and deep structures, and the nipple becomes retracted. It occurs in the older age groups and is almost indistinguishable from cancer. More rarely it presents as a nodular swelling of the breast clinically resembling a fibroadenoma, but biopsy shows a typical tuberculous lesion. The disease progresses and no case of spontaneous resolution has been recorded. The prognosis in the secondary type was considered by Morgen (1931) to be very grave, but recent advances in chemotherapeutic treatment may greatly improve this depressing outlook.

**Differential Diagnosis.**—

*a. Carcinoma.*—Tuberculous mastitis usually occurs at an earlier age, and progresses with greater rapidity than does a cancer. Pain is more marked in tubercle, and axillary glandular enlargement is more frequent in occurrence and earlier in onset. Discharge from the nipple, though rare in most carcinomas of the breast, is not infrequent in tubercle.

*b. Acute Mastitis.*—The condition may be very similar, but tubercle is usually of more insidious onset and slower progress.

*c. Actinomycosis* may resemble disseminated tuberculous mastitis, which characteristically forms multiple sinuses, but the occurrence of sulphur granules and the identification of the fungus will differentiate the conditions.

*d.* '*Chronic Mastitis*'.—Fixity to skin and deep structures characteristic of tuberculous mastitis is rare in simple 'chronic mastitis'.

Radiography of the chest in cases suspected of tubercle, and routine biopsy of doubtful breast swellings, may lead, as it has done in our series, to a more frequent diagnosis of tubercle, the incidence of which may be greater than the literature would suggest.

## CASE REPORTS

*Case* 1.—J. Y.

HISTORY.—In May, 1949, when seven months' pregnant, the patient noticed that the right breast was slightly red. On touching the breast she felt a small swelling near the nipple which was not tender and did not throb. The condition was treated with penicillin and poultices for one week, apparently without effect, and then she came to hospital. When first seen she appeared to be a healthy young woman, apart from a small fluctuant subareolar abscess just to the medial side of the nipple. This abscess was incised and the pus sent for examination. Direct smear failed to show any organisms and on culture there was no growth. The negative culture was thought to be due to the penicillin, which she had been given prior to her admission.

Following the operation, healing took place rapidly for a time but then ceased, leaving a small sinus. This sinus persisted despite various forms of local treatment.

On July 15, two months after the first examination, her child was born and steps were taken to suppress lactation, as it was thought that when the breasts became inactive the sinus would heal. However, it persisted and continued to discharge thick yellowish pus.

Six weeks after the birth of the child the sinus remained much the same, and the possibility of tuberculous infection was first considered.

On August 31 the sinus was excised and the denuded area saucerized. Histological examination of the sinus showed chronic inflammatory granulation tissue and tubercles, and in one of the tubercles acid-fast bacilli were seen.

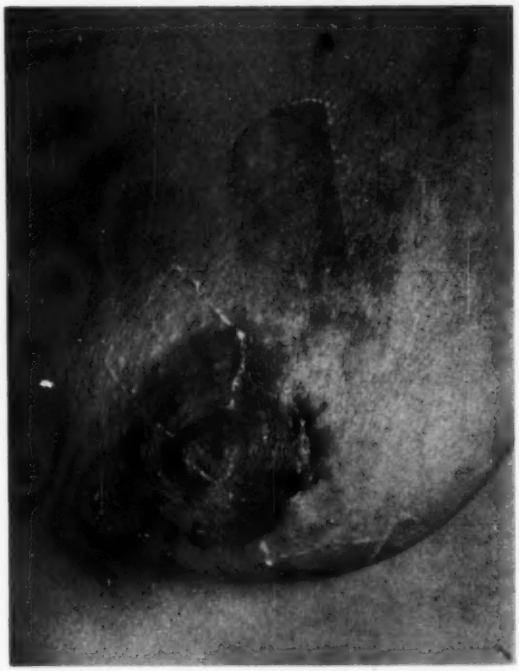

FIG. 586.—*Case* 1. The two openings of the tuberculous sinus are seen at the outer edge of the areola.

Despite this report the breast healed rapidly, until by Sept. 16 there was only a small sinus present (*Figs.* 586, 587). In view of the diagnosis, it was arranged for her to come into hospital for a more radical removal of the infected area.

She was re-admitted to hospital in October. Careful inquiry as to previous illness revealed no evidence of former tuberculous disease. She had had no lymph-node enlargement, no history of pleurisy, and no chronic cough. The family history was clear, excepting a vague history of one sister who was treated in a nursing home for enlarged glands in the neck at the age of 3 years. Radiography of the patient's husband and of her 5-year-old child showed no evidence of a pulmonary tuberculous lesion.

ON EXAMINATION.—Her general condition was excellent and there was no loss of weight. There was no evidence of lymph-gland enlargement, and in particular no glands could be palpated in the axillæ or neck.

*Radiography of the Chest* showed some old scarring in the left mid-zone but no recent active infection. Bacteriological investigation of the urine failed to demonstrate any tuberculous bacilluria.

The right breast presented a discharging sinus to the medial side of the nipple on the peripheral margin of the areola. The sinus was subcutaneous, and there was no induration of the surrounding tissue. The remainder of the breast tissue was normal, as also was the left breast. It was decided that a wide excision of the sinus *en bloc* should be attempted and this was carried out on Nov. 14.

PATHOLOGICAL REPORT.—The section report was as follows:—

"A wedge of breast tissue 4 × 1·5 × 1·5 cm. was received.

"Section through the main sinus shows caseation with surrounding *tuberculous granulation tissue* and some outlying follicles.

"Section through the deep layer and through the ends of the piece show no disease.

FIG. 587.—*Case* 1. A probe has been inserted into the tuberculous sinus to show its length and superficial situation.

"Section along the thick edge of the piece shows a tuberculous sinus lying in its deeper part and therefore the resection is *not clear of the disease.*

"No tubercle bacilli were demonstrated."

Part of the section is shown in *Fig.* 588.

PROGRESS.—Following operation the breast healed satisfactorily, but three months later small blister-like elevations appeared at the operation site and the scar broke down and discharged thick white pus. In spite of this the patient's condition remained remarkably good. There was no fever and a further radiograph of chest was clear. In view of the recurrence of the sinus the patient

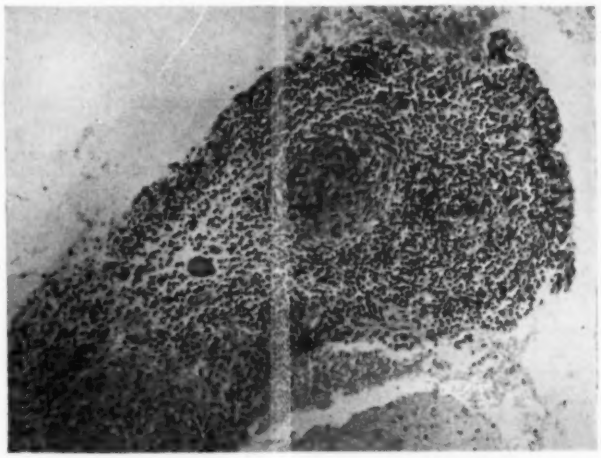

FIG. 588.—*Case* 1. Photomicrograph showing tubercles in the breast tissue removed when the sinus shown in *Fig.* 586 was excised. (× 87·5.)

was re-admitted to hospital with a view to treatment with streptomycin and P.A.S. Unfortunately, she herself was very anxious to have the disease eradicated surgically and a local mastectomy was accordingly carried out.

*Case* 2.—D. B., a married woman aged 27, first developed trouble in the left breast six weeks after the birth of her second child in April, 1948. She noticed a painless lump in the lower part of the breast ; but she was able to continue feeding her infant for some weeks. Later the swelling became painful and an abscess formed which required incision. The swelling and pain rapidly subsided following this operation, but three weeks later the induration reappeared and the sinus continued to discharge.

FIG. 589.—*Case* 2. The opening of the sinus is shown at the outer edge of the areola. Outlined is the area of induration.

ON EXAMINATION.—Three months after the onset of her symptoms ; the lower quadrants of the left breast were indurated and there was a chronic discharging sinus below and medial to the nipple. The appearance of this sinus and the extent of the surrounding induration are shown in *Fig.* 589. No enlargement of the axillary glands was noted.

*Radiography of the Chest* showed no evidence of tuberculosis, and the B.S.R. was 23.

*Biopsy of the Sinus Wall* was carried out on Oct. 12, and microscopy showed tuberculous granulation tissue with superimposed acute pyogenic inflammation.

On Nov. 4 a local mastectomy was performed and the wound healed rapidly and completely in ten days. Section of the operation specimen showed the characteristic histological appearances of tuberculosis (*Fig.* 590).

PROGRESS.—The patient recovered well after her operation, and one year later was delivered of her third child. She was able to carry out breast feeding from the remaining breast without difficulty and at a recent examination was in good health.

**Comment.**—In this case the condition developed in a patient who was in good health, and who had no personal or family history of tuberculous infection.

*Case* 3.—B. D., a married woman aged 23.

HISTORY.—The patient was quite well until July, 1944, when she developed bilateral apical tuberculosis with a left-sided pleurisy and a positive sputum.

She was then transferred to a sanatorium, where she remained until April, 1945, when she took her own discharge. Soon after leaving the sanatorium a small painless swelling developed in the breast over the 5th left costochondral junction. It gradually increased in size, and became cystic. In August, the swelling was aspirated and a few drops of pus were obtained, which on examination were found to contain tubercle bacilli. The cavity was injected with indigocarmine and then explored. The track passed to the right of the sternum, but no definite connexion could be found with a costochondral junction or rib. The sinus was curetted and then sutured. Eventually, over a year later, in September, 1946, it completely healed.

FIG. 590.—*Case* 2. A section through the indurated area of the breast, showing the appearances of tuberculosis. (× 35.)

After this the patient was well, became pregnant, and in March, 1948, had a normal delivery. She breast-fed the baby for six weeks, but then a relatively painless swelling appeared in the left breast in the region of the old scar.

This swelling gradually increased in size and spread across to the right breast, and discharged through a small sinus in this breast. The scar in the left breast remained healed, and the sinus in the right breast healed in about five weeks.

The sinuses in the breasts remained healed, and the patient was well until July, 1949, when she developed hæmaturia and strangury. A diagnosis of tuberculosis of the right kidney was made and in January, 1950, a right nephrectomy was carried out. On histological examination this diagnosis of a tuberculous kidney was confirmed.

The patient was first referred to us in June, 1950, on account of another small sinus which had arisen in the midline over the lower part of the sternum.

PAST HISTORY.—Apart from these complaints the patient had always been healthy, and there was no evidence of previous tuberculous infection.

*Family History*.—Two sisters developed pleurisy in 1944, at the same time as the patient first became ill. At this time they were all sleeping in an air-raid shelter. The other members of her family, including her husband and child, are free from tuberculosis.

ON EXAMINATION.—A pale but well-nourished young woman. Apyrexial. Free from enlarged glands in the neck or axillæ.

*The Breasts* (*Fig.* 591).—These were of relatively normal contour. In both inner lower quadrants there was slight induration, but no discrete tumours were palpable

and there was no tenderness. On the left side there was a long scar running from the middle of the sternum obliquely downwards towards the nipple, while on the

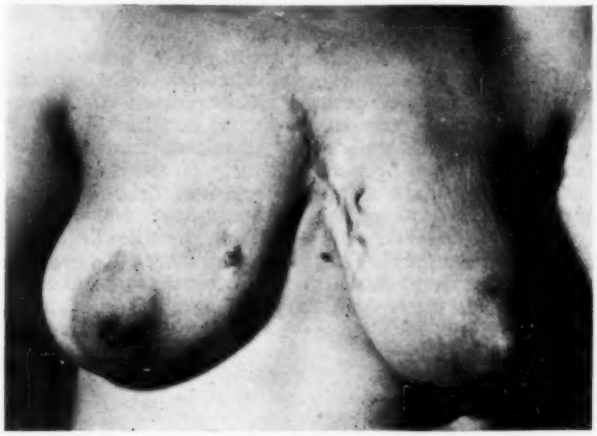

FIG. 591.—*Case* 3. Shows scarring in both breasts which had resulted from tuberculous sinuses. A small sinus is present in the midline over the lower part of the sternum.

right side there was a round scar which was soundly healed. Just to the left of the xiphisternum was a small sinus which discharged intermittently.

Radiography of the sternum, ribs, and costochondral junctions failed to show any abnormality.

Radiography of the chest showed infiltration of both upper zones.

Tubercle bacilli were found in the sputum.

*Case* 4.—A. R., a married woman aged 23.

HISTORY.—This patient, a native of Nigeria, was well until August, 1948, when she first noticed a painless swelling in the left axilla. This gradually increased in size, and in January, 1949, a mass appeared on the right side of the neck. Further swellings subsequently developed on both sides of the neck and she attended hospital for the first time in October, 1949. There were no other symptoms and she felt quite well. There was no

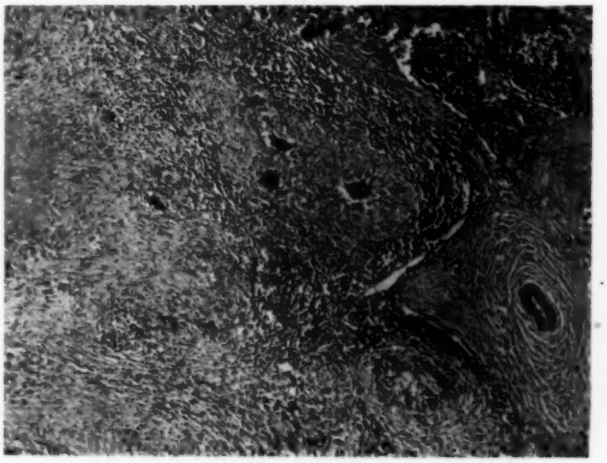

FIG. 593.—*Case* 4. Photomicrograph showing the characteristic changes of tuberculosis in a section from the lymph-node removed for biopsy. This lymph-node was situated under the outer border of pectoralis major about 1½ in. above the swelling in the breast. (× 45.)

cough or loss of weight, and there were no urinary symptoms.

The patient was three months' pregnant and the Friedman test was positive. The patient had had one previous pregnancy five years before. The family history and past history were difficult to obtain, but as far as could be ascertained there was nothing significant in them.

FIG. 592.—*Case* 4. Outlined are some of the enlarged lymph-nodes on the right side of the neck. On the left side there were many small discrete lymph-nodes.

ON EXAMINATION.—The patient was a tall, thin, young West African native who appeared to be in good health.

*Neck.*—On the right side there was a chain of large matted lymph-nodes extending from the subauricular region

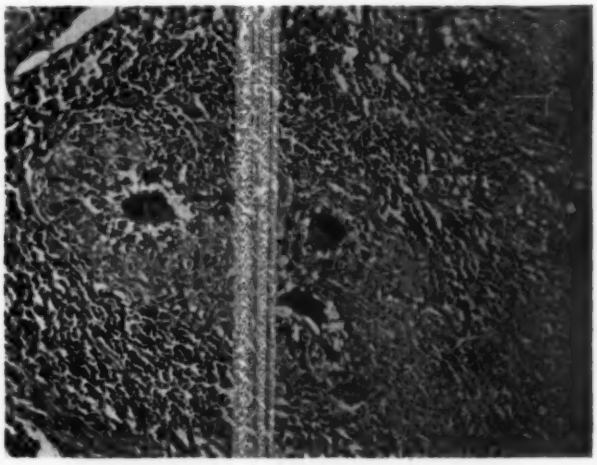

FIG. 594.—*Case* 4. Typical tubercles seen on greater magnification of part of *Fig.* 593. (× 87·5.)

down to, and behind, the clavicle. The nodes were painless, and not attached to skin. On the left side there were many small discrete lymph-nodes palpable. (*Fig.* 592.)

*Axillæ.*—On both sides there were large fixed masses of lymph-nodes, with no attachment to skin and no evidence of caseation.

*The Epitrochlear Glands* were enlarged on both sides. *The Inguinal Glands* were not significantly enlarged.

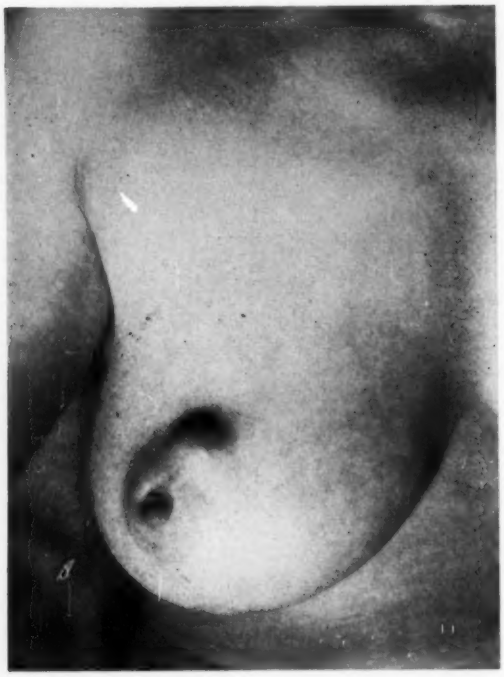

FIG. 595.—*Case* 5. The right breast, showing a small area of reddening and induration of the skin deep to which there was a mass 3 in. in diameter. The nipple is retracted.

*The Breasts* showed conspicuous asymmetry, the left being the larger. In the upper, outer quadrant of this breast there was a firm, slightly tender, irregular mass, with no attachment to the deeper structures, but with attachment to the skin and marked *peau d'orange*.

The spleen was not palpable and the liver was not enlarged.

There were no abnormal physical signs in the lungs, but the radiograph showed scarring in the left apical region, with recent tuberculous infiltration of the left upper and middle zones.

*Sputum.*—Eight specimens were examined and cultured and no acid-fast bacilli were found.

*W. R. and Kahn* were negative.

*Blood-count.*—Hb 81 per cent. W.B.C. 7000; Polymorphs 60 per cent; Eosinophils 1 per cent; Lymphocytes 32 per cent.

*Biopsy* was performed of a lymph-node from the outer border of the left pectoralis major. *Histological Report:* "The lymph-node is largely replaced by tuberculous granulation tissue arranged in peripheral follicles and confluent caseous masses. Judging by the degree of fibrosis present the lesion is of long standing. No tubercle bacilli were found in Ziehl-Neelsen stained sections or by fluorescent microscopy." (*Figs.* 593, 594).

SUBSEQUENT PROGRESS.—

Nov. 10, 1949: Started on a course of streptomycin 1 g. daily and Sod. P.A.S. 5 g. 4 times a day.

Nov. 23: Pregnancy terminated by hysterotomy.

Nov. 27: Mass in the left breast had almost disappeared. Glands in axilla and neck were much smaller. Area of infiltration in left lung also smaller.

Jan. 26, 1950: Streptomycin and P.A.S. stopped.

Jan. 31: Discharged to convalescence.

**Comment.**—This patient was undoubtedly suffering from tuberculosis, the presenting symptoms of which were generalized lymphatic enlargement, a form of tuberculosis not at all uncommon in negroes. It was considered that most probably the mass in the left breast was due to tuberculosis in view of the positive biopsy of the adjacent lymph-gland, and the very good response to streptomycin and P.A.S., but the final proof of breast biopsy was not obtained.

Case 5.—G. T., a married woman aged 36, came to hospital in January, 1951, complaining of a painless swelling in the right breast which she had first noticed six weeks previously. The swelling had slowly increased in size, but had remained painless. She had one child, born in 1948, which she had breast-fed without any difficulty. There was no history of a recent injury.

FIG. 596.—*Case* 5. A photomicrograph showing breast tissue and tuberculous granulation tissue. (× 37·5.)

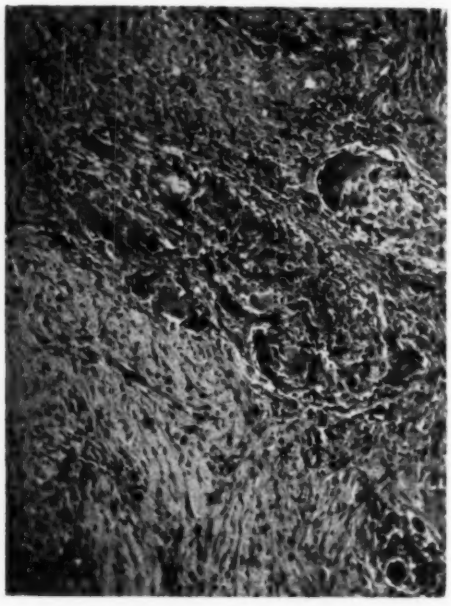

FIG. 597.—*Case* 5. Showing typical tubercles on greater magnification of part of *Fig.* 596. (× 87·5.)

*Past History.*—When 3 years old she developed tuberculosis of the spine and was under treatment in hospital for seven years. During this time a tuberculous abscess developed in the region of the left iliac crest and was drained.

At the age of 10 she was discharged from hospital and had not had any further trouble with her spine, and had had no other serious illnesses.

*Family History.*—Her mother and father are alive and well, but one brother has a tuberculous knee. Her husband and child are both well and free from any signs of tuberculosis.

ON EXAMINATION.—The patient was a well-nourished, healthy-looking woman of rather short stature. No obvious deformity of the spine was visible.

*The Right Breast* (*Fig.* 595).—The right nipple was retracted and just above it a small elevated area of reddened skin could be seen. On palpation there was a hard, painless mass about 3 × 3 in. in the upper half of the breast. On pressing the mass the small elevated area, previously mentioned, distended with fluid. The surface of the mass was nodular, but it was not attached to the deeper structures and was only attached to the skin in one small area. No enlarged lymph-nodes could be palpated in the right axilla or in the right supraclavicular fossa. The left breast was normal, as were the axilla and supraclavicular fossa on this side.

*Spine.*—There was a fixed kyphosis in the upper lumbar region, and a soundly healed scar over the left iliac crest. Radiography of the spine showed some collapse of L.1, 2, 3, and 4, the rest of the spine being normal. Radiographs of the lungs showed no evidence of tuberculosis.

A clinical diagnosis of tuberculous abscess of the breast was made.

*Biopsy of the mass* to confirm this diagnosis was carried out on Feb. 8. The incision was made through healthy skin and the mass was found to consist of a large, thick-walled abscess containing yellow pus. Some of the pus was sent for culture and a piece of the abscess wall taken for histological examination (*Figs.* 596, 597). The incision was closed without drainage. *Histological report*: "There is recognizable breast tissue present in which there is tuberculous granulation tissue and caseation. Some small follicles with epithelioid cells and giant cells are present. Tubercle bacilli were not found, but in spite of this it is considered this lesion is tuberculous."

*Culture* of the pus and guinea-pig inoculation were positive for *Myco. tuberculosis.*

SUBSEQUENT PROGRESS.—On Feb. 8, the day of the biopsy, the patient was started on a course of streptomycin ½ g. twice a day and P.A.S. 5 g. four times a day. This treatment was continued for six weeks.

On Feb. 21 the patient was discharged from hospital. The incision had healed by first intention and the mass in the upper part of the breast was much smaller. (*Fig.* 598.)

On Feb. 28 fibrous cords running from the lower part of the mass in the breast to the upper abdomen and extending downwards almost to the umbilicus, were noticed for the first time (*Fig.* 599). The mass in the breast was firmer and smaller and the nipple was no longer retracted. It was thought that this fibrous cord was most probably a lymphatic channel which had been involved in the tuberculous process and had become apparent as the result of fibrosis during the process of healing.

FIG. 598.—*Case* 5. Taken on March 27, 1951, approximately seven weeks after biopsy, and showing that primary healing of the incision has occurred and that the skin over the swelling is almost normal. The nipple is no longer retracted.

FIG. 599.—*Case* 5. Shows the right breast elevated to display fibrous cords running from the under-surface of the breast almost to the umbilicus.

On March 21 the course of chemotherapy was stopped. The mass in the breast was only 1 in. in diameter and the fibrous cord running down towards the umbilicus was still palpable.

On May 30 the lump in the breast had almost disappeared and the fibrous cord could no longer be palpated.

On June 27 the breast felt quite normal.

## DISCUSSION

*Cases* 1 and 2 illustrate the 'primary' type of tuberculous mastitis, occurring in young married women under the age of 30. In both cases the disease occurred in association with pregnancy, and in both a diagnosis of breast abscess was made on clinical grounds. The general health in each patient was good and there was no history of previous tuberculosis, or of tuberculosis in the family history. Excision of the breast led to complete cure, and one of the

patients (*Case* 2) had a child within a year of her mastectomy, which she was able to breast-feed without difficulty and without any re-appearance of disease in the remaining breast. The site of the lesion in both cases was at the outer margin of the areola, as is shown in *Figs.* 586 and 589.

The origin and route of infection in these two cases is not clear. As the breast lesion represented the only evidence of tuberculosis, it may well be that the organism reached the mammary gland via the blood-stream from an occult focus, although this occurrence seems unlikely in view of the work of Nagashima (1925), who has shown that in miliary tuberculosis the breast is never affected.

The fact that the lesions occur so near the areola suggests the possibility of ductal infection, but we are unable to substantiate this by evidence of contact with known tuberculous subjects or by histology.

There was no evidence in these cases that the infection was of lymphatic origin, though we do not exclude this route, since minor degrees of tuberculous lymphadenitis in the mediastinum are so easily overlooked. The site of the lesion was certainly in proximity to the subareolar plexus of Sappey, but there is no proof that this plexus was in fact infected.

*Cases* 3, 4, and 5 represent the ' secondary ' type of the disease in which the patient's health is already undermined by well-established tubercle in other sites, and in which the breast condition is but a further manifestation of the general disease. In *Case* 3 the primary lesion was in the apical and mid-pulmonary zones and it is interesting to note that the operative findings did not support the presence of a lesion in the costochondral junctions or the sternum, though this was specifically sought. The sinus was injected with indigocarmine and was followed with great care and found to disappear into the intercostal space, and it is considered more likely that the origin was from a necrotic mediastinal focus.

*Case* 4 illustrates an even more extensive tuberculous infection occurring in a West African native, in whose race susceptibility to the disease is well recognized. This patient had pulmonary tubercle associated with cervical and axillary glandular enlargement, from which it is thought that retrograde spread from the axillary lesion to the upper and outer quadrants of the breast took place.

*Case* 5 is another example of the ' secondary ' type of tuberculous disease of the breast, the main lesion being situated in the lumbar spine. There being no other signs of tuberculosis in this patient, it must be assumed that the breast was infected from a small area of reactivity in the main tuberculous focus in the lumbar spine which was not clinically or radiologically detectable. The route by which the infection reached the breast must be considered. Hæmatogenous spread is a possibility, but in view of the apparent resistance of the breast to this mode of infection (Nagashima, 1925 ; Raw, 1924), and the lack of any predisposing factor such as a recent lactation or injury in this case, this route seems unlikely. The spread of carcinoma from the breast to the abdominal cavity by the epigastric lymphatics has been so frequently noted that this avenue has been referred to as the ' dangerous angle '. It is our belief that in *Case* 5 the breast was infected by lymphatic spread from the vertebral lesion, and that the route of infection was similar to that of cancerous spread, apart from the direction, which in the case of tubercle is reversed. This view is supported by the fact that owing to involvement of the lumbar and para-aortic lymph-nodes and their efferent channels in the tuberculous process of childhood, lymphatic drainage of the lumbar vertebræ must now be by abnormal routes—most probably to the epigastric region. The fibrous cords already noted (*Fig.* 599) are the lymphatic channels from the umbilical region to the breast in which healing is occurring by fibrosis.

We have had no cases of the sclerotic type of mastitis which present such a resemblance to carcinoma, but have noted asymmetrical retraction of the nipple in 2 instances.

## TREATMENT

The surgical treatment of tuberculosis may become modified by the use of the new antibiotics effective against the tubercle bacillus. Formerly, quite radical surgical measures have been advocated, but it may well be that surgical intervention may be to some extent replaced by the use of streptomycin and para-amino-salicylic acid, as it has been in pyogenic infections sensitive to penicillin and the sulphonamides.

In the ' primary ' types of tuberculosis it has been the usual procedure to excise the breast, but in view of the small and localized nature of the lesion in this type, local wedge resection, combined with chemotherapy, should prove adequate.

In the ' secondary ' type of disease, surgical intervention has been limited to such measures as curettage and excision of sinuses. In certain cases, where the lesion has been confined to breast and only a small number of axillary glands have been involved, a modified form of radical mastectomy has been carried out. With the aid of chemotherapy, localized surgical measures will, we think, prove adequate if the response to streptomycin and P.A.S. is favourable.

## PROGNOSIS

Formerly the outlook in ' primary ' cases of tuberculosis of the breast was considered good, provided the breast was removed reasonably promptly. This operation was justified by the belief that the lesion never undergoes spontaneous resolution. We consider that with the advent of streptomycin the outlook is now greatly improved and the need for extensive surgery less.

In the ' secondary ' type the prognosis is determined by the extent and severity of the general infection and by its response to chemotherapy.

## SUMMARY

The aetiology, pathology, symptomatology, and diagnosis of tuberculous mastitis is reviewed and the importance of the lymphatic route of infection is stressed.

Five cases are recorded, 2 of ' primary ' and 3 of ' secondary ' type.

The treatment is discussed and the impact of the new antibiotics, in conjunction with surgery, is

considered to justify a much more hopeful outlook and a less radical surgical treatment.

We wish to thank Dr. C. V. Harrison, of the Department of Pathology of the Post-Graduate Medical School of London, for the reports on the section in *Cases* 1, 4, and 5; Dr. Miller, of Sutton and Cheam Hospital, for the report on the section in *Case* 2; and Dr. A. L. Wyman, of Fulham Hospital, for details of the early management of *Case* 3.

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# ADAMANTINOMA OF THE TIBIA

## REPORT OF A CASE

BY V. S. MANGALIK, PROFESSOR OF PATHOLOGY, AND
R. M. LAL MEHROTRA, LECTURER IN PATHOLOGY
FROM THE DEPARTMENT OF PATHOLOGY, THE UNIVERSITY, LUCKNOW, INDIA

ADAMANTINOMATA—primary epithelial tumours—arising in the jaw and in relation to the pituitary gland have been long recognized. The occurrence of such tumours in the long bones of the extremities is sufficiently rare to justify an addition to the cases already reported. It is proposed in this paper to report the clinical and pathological data of an additional case with a short review of the available literature.

### CASE REPORT

A., aged 40 years, a 'ward boy', was admitted to Gandhi Memorial Hospital, Lucknow, on Sept. 4, 1949, with a painful swelling on his left knee. He gave a history of injury to the left leg due to a fall sustained while lifting a stretcher a year ago. Since then he had been getting occasional pain in the left lower limb. A few months later a swelling appeared over the left knee. He was admitted to the hospital and a diagnosis of osteo-arthritis was made. As he had no relief in his pain, he left the hospital and went home. There he tried a number of indigenous treatments, including application of some plasters locally. The swelling on the knee gradually increased, as also the pain. Later on, another swelling appeared in the groin on the same side, which produced limitation of movements at the hip.

ON ADMISSION.—The patient appeared to be emaciated. He kept his left knee and thigh in flexed position. There was a hard, spindle-shaped swelling over the left knee extending from the tubercle of the tibia to about 3 in. above the patella. Skin over the swelling showed no marks of previous injury and was shiny and freely movable. Another small swelling (4 × 2 cm.) was noticed about the middle of the left leg, which was fixed to the middle third of the fibula. Skin over this swelling was also freely movable. Lymph-glands in the left inguinal region were enlarged, some were small, others were large (about 3 cm. in diameter). These glands were firm, discrete, and freely movable.

ON EXAMINATION.—

*Blood* examination done on Sept. 21 showed:—

| | |
|---|---|
| Total R.B.C. | 4,760,000 per c.mm. |
| Hæmoglobin | 13·2 g. per cent (88 per cent) |
| Total W.B.C. | 8800 per c.mm., with polymorphonuclears 77 per cent |
| Serum-alkaline-phosphatase | 9·0 units (Armstrong and King) |
| Serum-acid-phosphatase | 0·5 units |
| Serum-calcium | 11·5 mg. per cent |

*Urine* (Sept. 21): Albumin, absent; Bence-Jones's protein, absent.

*Radiography* of knee- and hip-joints was done on Sept. 10. The radiologist reported as follows: "Shows an appearance suggestive of osteoclastoma, upper end of the tibia. There is widening of the epiphysis of tibia and demineralization of its bony substance. The periosteum is still intact. Similar demineralization is present in the lower end of femur (*Figs.* 600, 601). Hip-joint shows no abnormality." Radiograph of chest done on Sept. 20 showed "normal appearance. No evidence of metastasis".

On Sept. 26 a lymph-gland biopsy from the inguinal tumour was done. The histological examination revealed evidence of metastasis from an epithelial tumour. "Section shows complete replacement of the lymphoid tissue by masses and columns of epithelial cells embedded in a dense fibrous stroma. The cells are polygonal, spheroidal, or oval in shape, with prominent vesicular nuclei and pink-staining cytoplasm. There is no cell-nest formation." On the appearance and the arrangement of the cells, a suggestion of adamantinoma of the tibia was made.

On Oct. 26 a punch biopsy was taken from the tumour in the upper end of the tibia. Histological examination showed the structure of an epithelial tumour resembling an adamantinoma.

OPERATION SPECIMEN.—On Nov. 10 amputation was performed by Dr. Pritam Das from the middle of the left thigh. The report of the amputated leg was as follows:—

"Gross.—

"The specimen consists of amputated lower part of the thigh and left leg. Skin over the amputated limb is freely movable and shiny in appearance. A longitudinal section through the middle of the bones of the knee-joint, shows widened out upper end of tibia (11 × 6·5 cm.) which is made up of white, firm tissue;

the bony structure appears to be completely destroyed. The borders of this mass are regular and well marked out from the surrounding soft tissues. Similar tissue has involved the cruciate ligaments, which have become thick (2 cm. in thickness) and has also extended to the

FIG. 600.—Radiograph of both knees. Anteroposterior view, showing widening of the upper end of left tibia and demineralization of its bony structure. The periosteum is intact.

lower condyles of femur. The articular surfaces of femur and tibia are intact. Lower down a small process 3 × 1 cm. arising from the mass in the epiphysis of the tibia is seen growing into the marrow of the shaft of tibia (*Fig.* 602).

" In the middle of the shaft of the fibula there is an oval swelling 7 × 4 cm., with a circumference of 11 cm. The swelling is firm, and in this region the shaft of the bone has been destroyed (*Fig.* 603). The swelling is covered by a tough white membrane, periosteum. Cut surface shows a similar appearance to that of the tumour in the upper end of the tibia.

" Microscopical.—

" Histological examination of the sections from the upper end of the tibia, cruciate ligaments, lower end of the femur, and the swelling in the shaft of the fibula show similar structure. They show (*Fig.* 604) masses

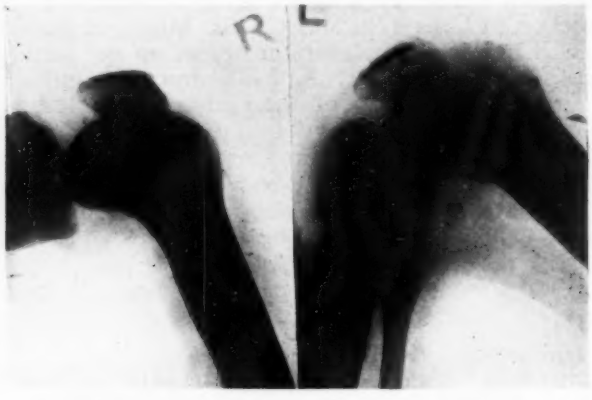


FIG. 601.—Radiograph of both knees. Lateral view.

and strands of epithelial cells embedded in a dense fibrous stroma. The epithelial masses are made up of polygonal, ovoid, or flat cells having large vesicular nuclei and abundant light pink-stained or vacuolated cytoplasm. The cells in the central portion of some

FIG. 602.—Longitudinal section through the bones of left knee-joint. Tumour is situated at the upper end of the tibia and has extended through the cruciate ligaments to the condyles of the femur. The soft parts have not been involved.

FIG. 603.—Side view: Radiograph taken after separation of bone from the amputated limb. Swelling in the middle of the shaft of the fibula; the bony structure in this region has been completely destroyed.

of these masses have undergone necrosis resulting in the formation of small cystic spaces which contain necrotic cellular debris or appear empty. Some of the epithelial strands show 'cell-nest' formation. The dense fibrous stroma contains few small irregular bone trabeculæ at places. The articular cartilage of the knee-joint has not been invaded by the epithelial cells."

On the basis of the various sections taken from the tumour mass, the punch biopsy, and the lymph-gland

biopsy done previously, a diagnosis of primary epithelial tumour—adamantinoma of the tibia and fibula—with metastasis to inguinal lymph-glands was made.

Before making the diagnosis of adamantinoma in this case, we took into consideration the possibility of its being a metastasis from some other epithelial tumour. A thorough clinical examination of the patient, however, showed no other neoplastic lesion anywhere in the body. Radiographic examination of the bones of skull, ribs, vertebræ, and pelvis showed normal appearances. At the time of writing this paper (five months after the operation) the patient is well except for the enlarged glands in the inguinal region, for which he is being treated with deep rays. His general condition has very much improved after the operation and he can now walk with the aid of crutches.

FIG. 604.—Sections from the tumour. They show irregular masses and strands of epithelial cells embedded in dense fibrous stroma. A, 'Cell nest' formation and cystic degeneration is noticeable in the centre of some of these epithelial masses. (× 56.) B, The cells have vacuolated cytoplasm. (× 68.)

## DISCUSSION

Fisher (1913) was the first one to report a primary adamantinoma of the tibia. Richter in 1930 reported the second case. A third case was reported by Baker and Hawksley in 1931. Ryrie added another case in 1932. Holden and Gray (1934) added a fifth case and incidentally the first in American literature. In 1937 Bishop published another case. In 1938 Rehbock and Barber reported the seventh case. Wolfort and Sloane in 1938 added 2 more cases. The most recent case as far as we have been able to trace was reported by Thomas in 1939. Willis (1948) refers to 2 more cases reported by Oberling and others in 1938 and Petrov and Glasunow in 1933. We have not been able to get access to these case reports. So far it seems that only 12 cases of adamantinoma of the tibia have been published in the literature; ours is the thirteenth.

In *Table I* the data of reported cases have been analysed.

Analysis of these cases reveals that the tumour occurs at all ages and shows such wide variation in age as 12 years and 46 years. There seems to be no significant predilection for sex.

From a study of case reports it seems that the tumour once established tends to remain limited to the bone except in cases reported by Rehbock and Barber (1938) and Wolfort and Sloane (1938), where local infiltration to the muscles of the leg had occurred.

The tumour is localized to one site in the bone except in the case of Thomas (1939) where two discrete tumour masses were present in the upper and the lower thirds of the tibia. The case under report showed an unusual feature in having two distinct tumour masses—one in the upper end of the tibia and the other in the middle third of the fibula. The duration of symptoms before the patients came for operation has shown extreme variability; 8 years in the case of Ryrie (1932) to 4 months in the case reported by Wolfort and Sloane (1938). A history of trauma was available in almost all the cases. Ryrie (1932) obtained the history of trauma 8 years before the appearance of symptoms. The tumour being uncommon and rarely reported (13 cases in the course of thirty-seven years), the clinical diagnosis of adamantinoma was not considered in a single case.

It is generally recognized that adamantinomas, though they commonly produce local recurrences, very rarely produce metastasis to distant parts. Waterworth and Pullar (1948), in a recent review on the subject, have collected 8 cases of adamantinoma of the jaw where secondaries in the lung were observed, and mention that spread to the regional lymph-nodes has been encountered in many. Of the 12 cases of adamantinoma of the tibia reported in the literature there is only 1 case, reported by Petrov and Glasunow (1933), in which metastasis occurred in the inguinal lymph-nodes. A similar feature has been observed in the case under report, where the tumour not only spread locally through the cruciate ligaments to the femoral condyles but also produced a metastasis in the inguinal lymph-glands.

A study of the microscopical appearances as reported by the various authors shows that in most cases the epithelial growth was usually of the basal-cell type, but in some cases (Rehbock and Barber, 1938) the cell characters are distinctly epidermoid with cell-nest formation. Our case falls into the latter category.

Our knowledge about the histogenesis of these tumours is not clear. Fisher (1913), while reporting his case, suggested that these tumours arise from fœtal cell rests formed during intra-uterine life. Baker and Hawksley (1931) agree with Fisher, but they lay stress on the history of trauma which, according to them, is responsible for stimulating the ' rests ' into growth. Ryrie (1932), on the other hand, maintains that these tumours arise from implanted epithelial cells in the periosteum of the bone. This, he says, is due to the peculiar anatomical structure of the part, close proximity of the skin to the bone, the sharp anterior border of the tibia, and the fact that the skin in this area is more movable in the lateral than in the longitudinal direction. Thus a " shearing injury, a kick or a fall on a stair " tends to drag the soft tissues over the superficial bone, causing tearing of the tissues and their anchorage to the periosteum. The anchored tissue may get absorbed, but if recovery is not complete or ' thwarted ', an epithelial tumour arises. Willis (1948) agrees with Ryrie that trauma may be responsible for producing implantation of the epithelium on the periosteum, which may be followed by a tumour formation.

This sounds quite fascinating, but before one agrees with the theory of traumatic epithelial implantation on the surface of the tibia, the implants have to be demonstrated ; more so, in view of the fact that injury to the anterior border of the tibia is quite a common occurrence during life. If injury to the tibia can produce epithelial implants and subsequent tumour formation, one fails to understand why such tumours are not seen on the ulna, the upper end of which is very near the skin and is subjected to trauma with equal frequency.

*Table I.*—PRIMARY EPITHELIAL TUMOURS OF TIBIA (ADAMANTINOMA)

| CASE NO. | REPORTED BY | AGE IN YEARS AND SEX | SITE OF TUMOUR | DURATION OF SYMPTOMS IN MONTHS | HISTORY OF TRAUMA | CLINICAL DIAGNOSIS | RECURRENCES | METASTASIS |
|---|---|---|---|---|---|---|---|---|
| 1 | Fisher (1913) | 39 M. | Middle and lower third | 4 | Yes (5 mth.) | — | None | — |
| 2 | Richter (1930) | 12 M. | Middle third | 8 | Yes | Myelogenous sarcoma | (Amputation was done) | — |
| 3 | Baker and Hawksley (1931) | 46 M. | Lower third | 10 | Yes (10 mth.) | Myeloma | None till 2 months | — |
| 4 | Ryrie (1932) | 44 M. | Middle third | 96 | Yes (16 yr.) | Sarcoma | Yes, after 6 months | — |
| 5 | Petrov and Glasunow (1933) | — | — | — | — | — | — | Metastasis in regional lymph-glands |
| 6 | Holden and Gray (1934) | 36 F. | Lower third | 24 | Yes | Bone cyst | Yes, in 24 months | — |
| 7 | Bishop (1937) | 22 M. | Upper third | 36 | Yes | Giant-cell tumour | Yes, in 14 months | — |
| 8 | Rehbock and Barber (1938) | 24 F. | Lower third | 18 | Yes | Brodie's abscess | None till 8 months | Local widespread extension |
| 9 | Oberling, and others (1938) | — | — | — | — | — | — | — |
| 10 | Wolfort and Sloane (1938) | (*a*) 57 F. | Middle third | 4 | Yes | Fibrocystic disease | Yes, after 5 months | — |
| 11 | | (*b*) 18 F. | Lower half | 4 | Yes | — | Yes | Local infiltration in muscle |
| 12 | Thomas (1939) | 19 F. | Upper and lower third | 84 | Yes | Giant-cell tumour | Yes, in 10 months | — |
| 13 | Mangalik and Mehrotra (1952) | 40 M. | Upper end tibia and shaft of fibula | 12 | Yes | Osteoclastoma | Amputation | Inguinal lymph-glands. Local extension to lower end of femur |


## SUMMARY

1. A case of primary epithelial tumour of the tibia has been described.

2. The tumour in the tibia produced a local extension through the cruciate ligaments to the femoral condyles.

3. The tumour had produced metastasis in the regional inguinal lymph-nodes.

4. A similar tumour was found in the shaft of the fibula of the same leg.

5. A review of the cases reported in the literature is given and the histogenesis of these tumours is briefly discussed.


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# RECURRENT 'NODULAR GOITRE' IN CHILDREN

By R. H. HEPTINSTALL and SIR ARTHUR PORRITT
ST. MARY'S HOSPITAL, LONDON

Owing to the infrequency with which nodular goitre occurs in children, 3 cases of *recurrent* 'adenomata' which have been encountered are presented and their pathological nature, prognosis, and treatment discussed. Owing to the exigencies of war, it is regretted that clinical details are sparse.

## CASE REPORTS

*Case* 1.—A male child born in 1911 was first seen in 1920, at the age of 9. He was brought to the Out-patient Department complaining of a symptomless swelling in the neck which had first been noticed at the age of 6 and had subsequently for the ensuing three years gradually increased in size. He was operated upon in the same year (1920), a nodular goitre being removed by partial thyroidectomy (Mr. Gordon Bryan).

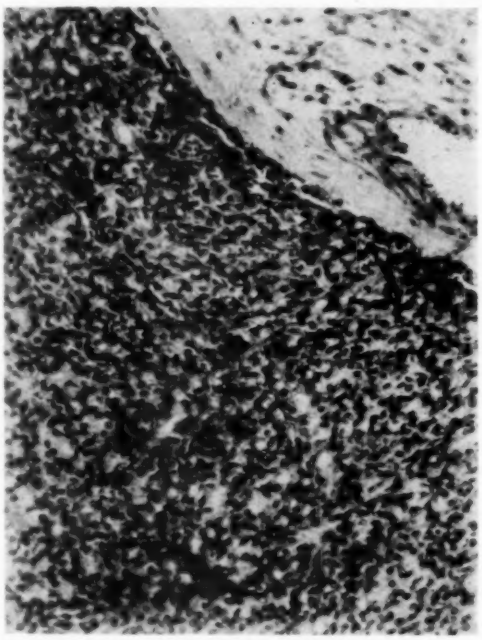

Fig. 605.—Nodule from first specimen of *Case* 1. Diffuse arrangement of cells with tendency to form acini. Hæmatoxylin and eosin. (× 142.)

The pathological report showed that nodules varied in size and consistency, but some were paler in colour and more solid. The microscopical picture showed the more solid nodules to be composed of diffuse sheets of cells, but always showing a tendency to form acini (*Fig.* 605). There was a variation in staining properties of the nuclei, but mitoses were infrequent. Neither capsular nor blood-vessel invasion was seen. Other nodules showed large vesicles with a tendency to papillary projections. In the surrounding thyroid tissue were tiny nodules consisting of small acini (*Fig.* 606). No colloid was seen in the specimen.

Almost immediately after the patient's discharge from hospital a reappearance of the swelling in the neck was noticed and thirteen months later he was re-admitted for a further operation (1921), more thyroid tissue being removed (Mr. Zachary Cope). Pathological examination gave a picture almost identical with those of the earlier sections (*Fig.* 607). After this second operation nothing untoward occurred until 1929, when, at the age of 18, he again sought advice for his steadily enlarging thyroid gland. Yet a third thyroid resection was performed by Mr. Gordon Bryan.

It has not proved possible since to trace this patient in person, but information from the Registrar-General's office leads us to assume that he is still alive. The pathological report on the tissue removed at the third operation was very similar to that in the first instance. Nodules up to 2·5 cm. in diameter had been removed, the largest of these being cystic, the smaller ones solid

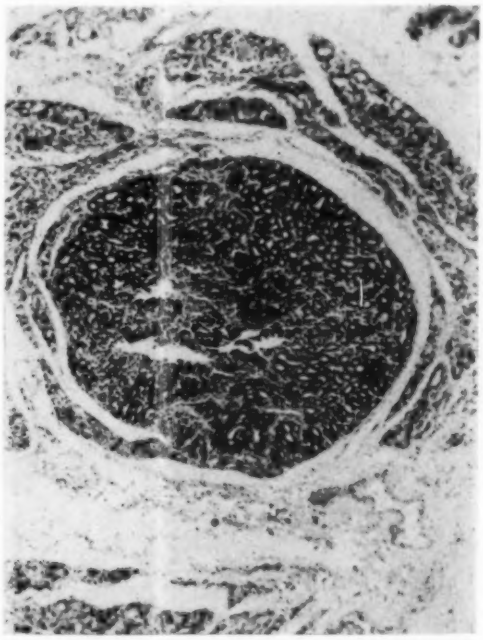

Fig. 606.—Small nodule from surrounding thyroid of first specimen of *Case* 1. Hæmatoxylin and eosin. (× 64.)

(*Fig.* 608). Some consisted of acini of varying sizes lined by cubical epithelium (*Fig.* 609), but others showed the same characteristics as those already described.

*Case* 2.—A male child, born in 1918, was first seen at the age of 13 years in 1931. He then complained of a swelling of the neck which was said to have been present since birth, but which had been increasing markedly during the last few years. He had had no dysphagia and there were no symptoms or signs suggestive of thyrotoxicosis. He was 4 ft. 4 in. in height and weighed only 4 st. He had never lived in a goitrous district, but had had a sister who was operated upon for a swelling of the thyroid (? adenoma) when 9 years old. Subsequent to this operation the goitre had recurred and two years later she had undergone a second operation, as a result of which she had died. (Unfortunately it has not been possible to obtain further details of the sister's case.)

In 1931 a left partial thyroidectomy was performed by Mr. Zachary Cope. Pathological report: The specimen was made up of several nodules, the largest measuring 3·0 cm. in diameter. The smaller ones were white in colour, whilst the largest had central hæmorrhage.

All were encapsulated. Microscopically the adenomata were composed of cubical and polygonal cells arranged

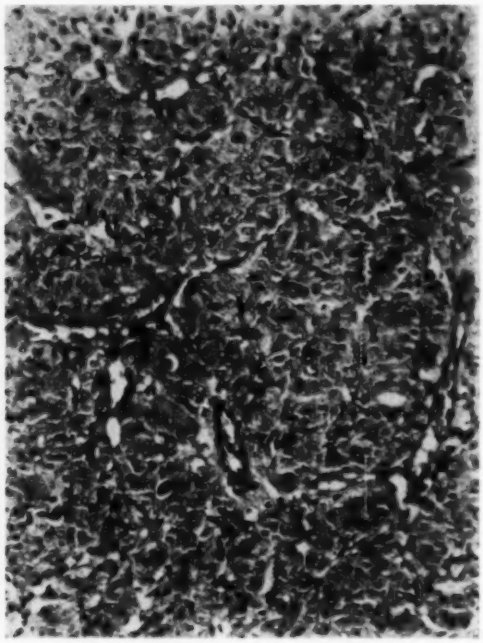

FIG. 607.—Nodule from second specimen of *Case* 1. Cells arranged in closely compressed acini separated by narrow channels. Hæmatoxylin and eosin. (× 142.)

in solid masses or in clusters resembling acini closely compressed (*Fig.* 610). Nuclei varied in size and staining intensity from vesicular to solid darkly staining

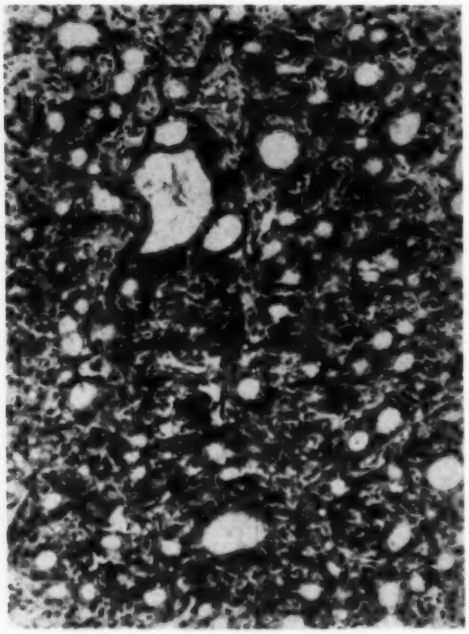

FIG. 609.—Nodule from third specimen of *Case* 1. Acini of varying sizes lined by cubical epithelium. Hæmatoxylin and eosin. (× 162.)

forms. Mitoses were scanty. Towards the centre of the nodules there were well-formed small acini, but no colloid was present. Tumour cells were found lying close to capillaries, but there was neither vascular nor capsular invasion.

In 1932 the patient was re-admitted complaining of further swelling of the neck. This was found to be mainly of the right lobe, and a partial thyroidectomy was carried out on this side (Mr. Zachary Cope), the specimen consisting of nodular thyroid tissue 4·5 × 4·0 × 2·5 cm.

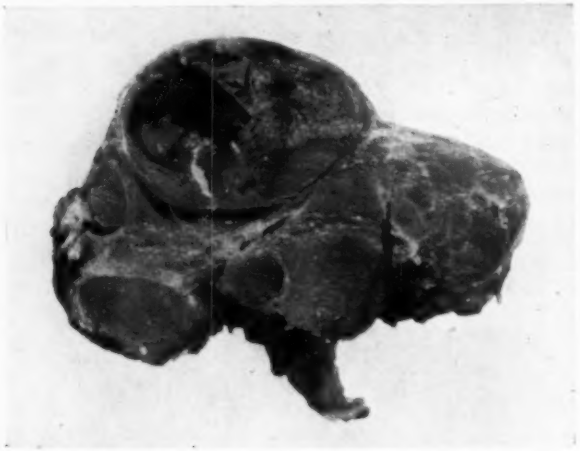

FIG. 608.—Specimen from third operation of *Case* 1. (× ⅔.)

made up of encapsulated adenomata (*Fig.* 611). Histological appearances were as before described, but with a greater tendency to form acini (*Fig.* 612).

Further recurrences and consequent partial thyroidectomies (Mr. Zachary Cope) took place in 1933 and 1934—the macroscopical and microscopical findings being similar to the previous specimens.

Following the fourth operation (1934) he received two courses of X-ray therapy, the dosage given being unknown. He did not, however, appear again until 1949

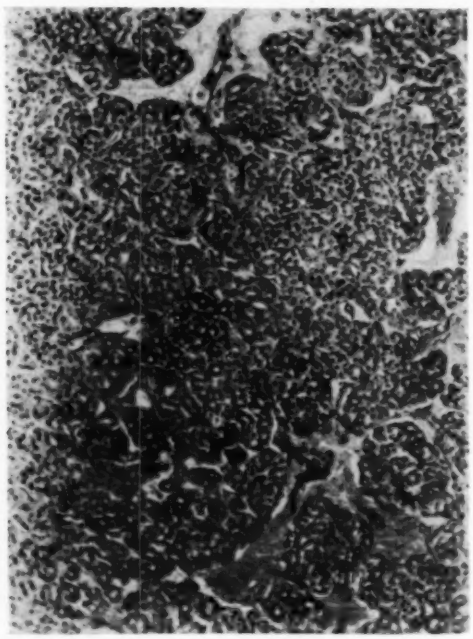

FIG. 610.—Nodule from first specimen of *Case* 2. Closely compressed small acini. Hæmatoxylin and eosin. (× 104.)

—then aged 31—when he once more complained of swelling of the neck, which had been increasing slowly for a number of years.

There were no real pressure signs nor any evidence of either hyper- or hypothyroidism. His weight remained

steady at 9 st. 10 lb. and his stature was small. Mentally he was alert and physically strong. The goitre on palpation was soft and resilient, but the trachea was clinically and radiologically deviated to the left, the bulk of the swelling being right-sided. He was given 1 gr. of thyroid daily over a period of four months. This led to a diminution in the circumferential measurement of the neck of 1½ in. When a stationary stage (*Fig.* 613, A, B) appeared to have been reached he underwent his fifth operation (A. E. P.)—a complete right hemithyroidectomy—a procedure which in view of his four previous surgical adventures and subsequent radiotherapy was not without its technical difficulties. A small portion of the left lobe was seen at operation and deliberately left. When last examined (1951) this nodule was visible and palpable

FIG. 611.—Specimen from second operation of *Case* 2. (× ⅔.)

just to the left of the midline, but had shown no tendency to increase in size (*Fig.* 613, C, D). The pathological report on tissue removed at this operation was: "The specimen measured 9·0 × 7·0 × 6·0 cm. and was made up of numerous adenomata up to 5·0 cm. in diameter. They were brown in colour and somewhat spongy in consistency. Microscopically the picture was varied, the most common appearance being that of small acini devoid of colloid lined by cubical epithelium (*Fig.* 614). Surrounding thyroid tissue showed fibrosis. This specimen appeared the most benign of the five."

The patient, now aged 33, was doing full heavy work and stated that he felt perfectly fit. There was no change in weight nor any signs of hypothyroidism. He had been given no thyroid since his last operation.

*Case* 3.—A female child born in 1932 was first seen in 1945, when 13 years old. She complained of a swelling in the neck which had first been noticed when she was 5 years of age. This had steadily increased in size since that time and had become very pronounced early in 1945. There were, nevertheless, no signs of obstruction nor any toxic symptoms, although occasional pain in the neck was experienced. She had never lived in a goitrous district, nor was there any relevant family history.

Examination in July, 1945, revealed a greatly enlarged soft nodular thyroid gland (*Fig.* 615). Preliminary treatment with thyroid extract (gr. 1, rising to gr. 2 daily) was instituted over a period of two months and resulted in a slight diminution in size of the gland. Partial thyroidectomy was carried out in two stages in October and November, 1945, by Sir Thomas Dunhill, approximately 5·0 × 2·5 × 2·5 cm. of thyroid tissue being left on each side.

The pathological report on the first specimen showed that it consisted of an irregular mass 8·0 × 6·0 × 4·0 cm. made up of numerous adenomata up to 4·0 cm. in diameter. Hæmorrhage had occurred into the largest. Microscopically the picture was that of small acini lined by cubical epithelium. Some acini were larger and were lined by taller cells. No colloid was present. Nuclei varied in staining intensity, but mitoses were infrequent. There was neither vascular nor capsular invasion.

The second specimen consisted of an irregular mass 10·0 × 6·0 × 4·0 cm. made up of several adenomata.

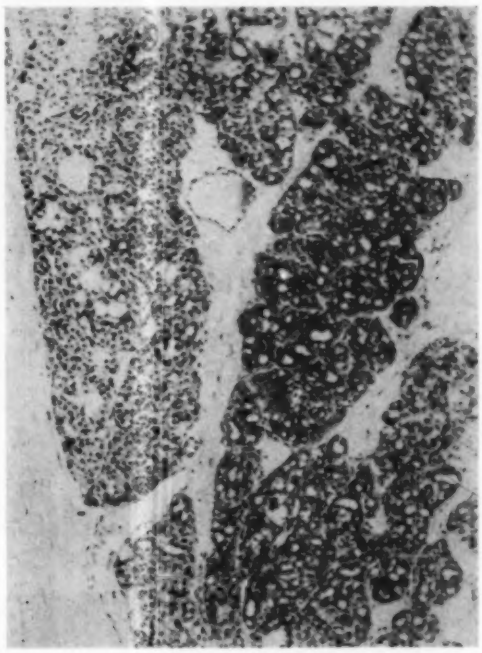

FIG. 612.—Nodule from second specimen of *Case* 2. Numerous small acini, more differentiated than previous specimen. Hæmatoxylin and eosin. (× 84.)

The three largest were cystic and measured up to 4·0 cm. in diameter. Microscopically the picture was similar to that of the first specimen, but in addition there were areas with papillary formations (*Fig.* 616). The surrounding thyroid tissue showed fibrosis and was devoid of colloid. Scattered amongst this tissue were small rounded nodules of more solid thyroid tissue, giving the impression of being embryo adenomata.

The patient's immediate post-operative course was uneventful, but within two months from the date of her discharge from hospital the thyroid swelling reappeared. In 1947 she was given two courses of deep X-ray therapy (dosage 600 v. and 400 v. respectively). In spite of this, the gland continued to enlarge and in 1948 she was re-admitted. The B.M.R. at this stage was −21 per cent, there being no clinical evidence of toxicity, but again a large nodular goitre was very evident—the left lobe being particularly prominent.

A six weeks' pre-operative course of thyroid extract (total dosage gr. 98) was given, which reduced the circumferential measurement of the gland by a little over 1 in. In October, 1948 (patient now aged 16), a complete left hemithyroidectomy was performed (A. E. P.), the remains of the right lobe being deliberately left.

The pathological report was: The specimen consisted of a mass 6·0 × 4·0 × 3·5 cm., the main adenoma in this being 4·0 × 3·0 × 2·5 cm. The latter was white in colour, with a hæmorrhagic centre (*Fig.* 617). Microscopically the main picture was one of small acini lined by cubical epithelium (*Fig.* 618). In some places there were papillary formations, but these were not conspicuous. Again there was neither vascular nor capsular invasion.

The patient was discharged, after a relatively smooth post-operative course, on a daily dose of gr. 1 of thyroid extract. After one month this was increased to gr. 1½ daily as the remaining nodule of the right lobe showed signs of increasing in size. Two months later, despite this treatment, the right lobe was obviously increasing rapidly in size and she was again admitted in April, 1950. The right lobe was harder than on previous occasions and irregular (*Fig.* 619). This lobe was also removed *in toto* (A. E. P.), thus completing a total thyroidectomy. Pathological examination: The specimen consisted of a nodular mass 6·5 × 5·0 × 3·5 cm., with adenomata up

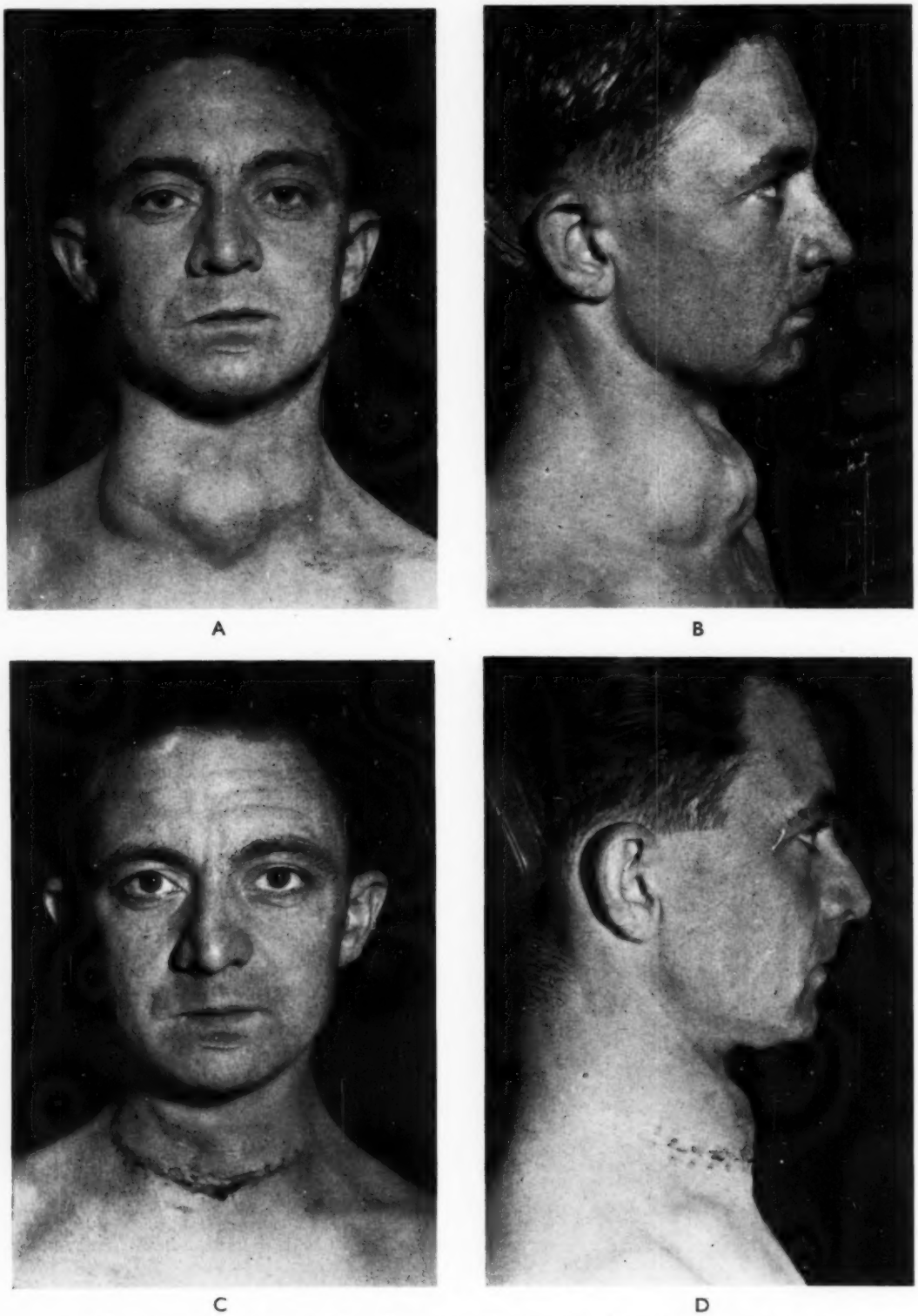


FIG. 613.—*Case* 2 before and immediately after fifth operation. (Anterior and lateral views.)

to 2·5 cm. in diameter. For the main part these were greyish-white in colour, the larger ones showing hæmorrhage (*Fig.* 620). Microscopically the picture was

FIG. 614.—Nodule from fifth specimen of *Case* 2. Numerous small acini arranged longitudinally. Hæmatoxylin and eosin. (× 84.)

varied. Some nodules showed solid sheets and yet others papillary processes. (*Fig.* 621.) Mitoses were not frequent

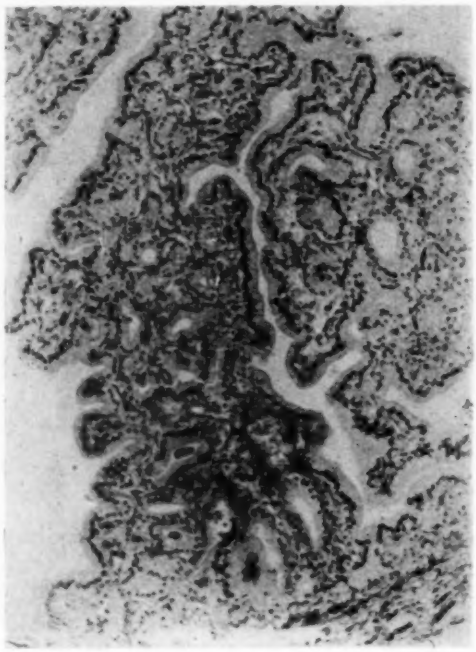

FIG. 616.—Nodule from second specimen of *Case* 3. Papillary processes projecting into acini. Hæmatoxylin and eosin. (× 84.)

and there was neither capsular nor vascular invasion. Numerous seedling nodules were found in the surrounding thyroid tissue.

After this, her fourth operation, the patient was discharged without being given thyroid extract. It was obvious, however, after three months, that some replacement would be necessary as she showed definite signs of lethargy. For three months gr. ½ per day was tried;

FIG. 615.—*Case* 3 before first operation.

the dose was then increased to gr. 1 daily and the patient remains well and is satisfactorily carrying out the duties of a dentist's receptionist (aged 19). A degree of apathy and listlessness at the end of the day's work has recently (15 months after the final operation) necessitated the raising of the daily dose to gr 1½. Local condition of neck at this stage is shown in *Fig.* 622.

## DISCUSSION

**Incidence of Nodular Goitre in Children.**—Nodular goitre is not commonly seen in children, but appears to increase in frequency with advancing

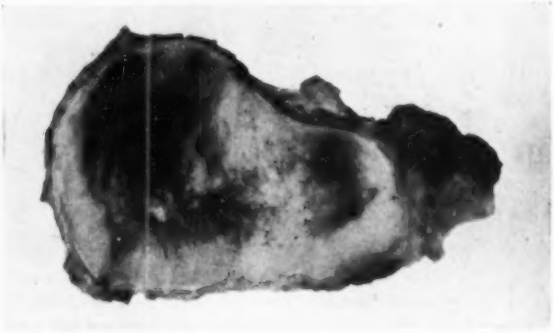

FIG. 617.—Specimen from third operation of *Case* 3. (× ⅔.)

years. Aschoff (1924), working in a goitrous district, stated that he had never seen them in the prepuberty period, and maintained that they do not begin to appear until puberty. Wegelin (1926), working in Berne, found the condition in only 2 out of 106 routine autopsies under the age of 10 years, an incidence of 1·9 per cent. Rice (1931), in a comparable study in Minnesota, another goitrous area, found only 1 case

out of 61 routine autopsies under the age of 10 years, an incidence of 1·6 per cent. Cattell (1933), from the Lahey Clinic, described only 3 cases under the age of 15 years in a discussion on thyroid disease

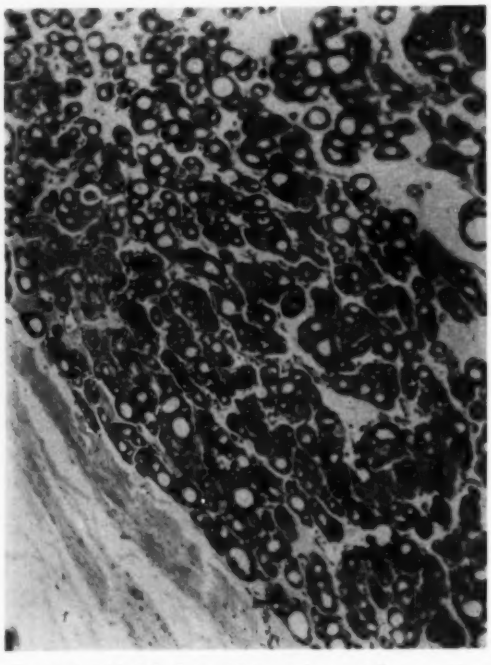

FIG. 618.—Nodule from third specimen of *Case* 3. Numerous small acini lined by cubical epithelium. Hæmatoxylin and eosin. (× 84.)

in children, and Joll (1932) mentioned the rarity of diffuse nodular goitre in children. Kennedy (1940), however, encountered 62 cases of nodular goitre in a vast amount of material at the Mayo Clinic.

On the subject of recurrent adenomata in children, the literature is surprisingly scanty. Wilson (1921)

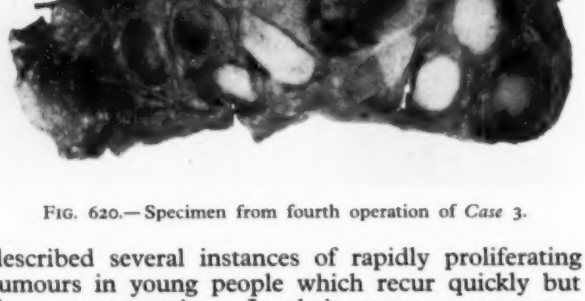

FIG. 620.—Specimen from fourth operation of *Case* 3.

described several instances of rapidly proliferating tumours in young people which recur quickly but do not metastasize. In their paper on recurrent thyroid adenomata, Poate and Macindoe (1940) included only one young patient (aged 14 years at the time of the first of 4 operations for recurrences).

**Origin and Nature of Nodular Goitre in Children.**—The cases described above occurred in children, two boys and one girl, aged 9, 13, and 13 years respectively, at the time of the first operation. In the two latter cases enlargement of the gland had been noticed for many years prior to this. The family history is negative with the exception of *Case* 2, and none has ever lived in a goitrous district. In no case was thyrotoxicosis present.

FIG. 619.—*Case* 3 before fourth operation

The origin of nodular goitre is a subject on which there are divergent views. Wölfler (1883) differentiated between colloid adenoma and fœtal adenoma, stating that the latter arose from fœtal rests. At a

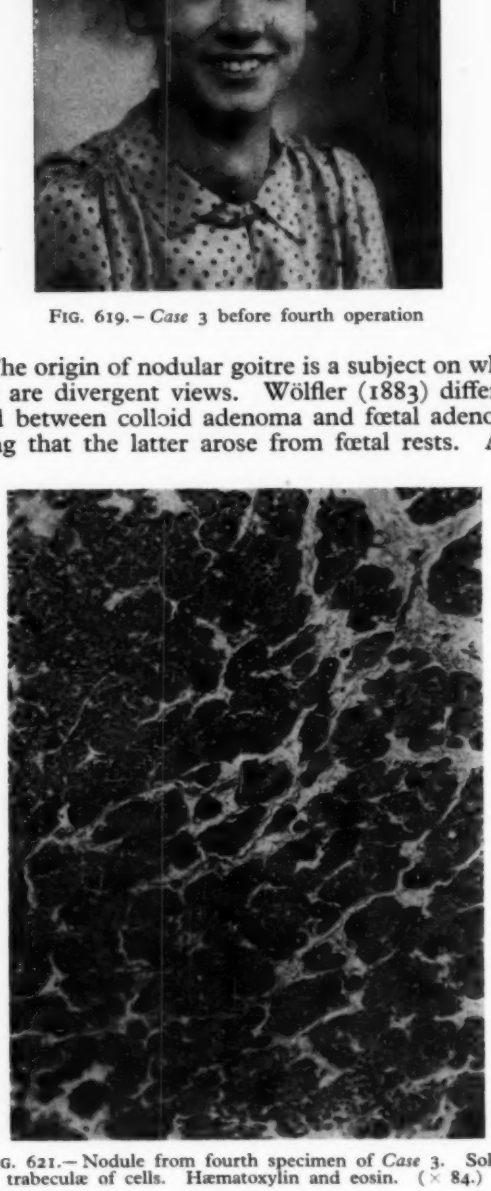

FIG. 621.—Nodule from fourth specimen of *Case* 3. Solid trabeculæ of cells. Hæmatoxylin and eosin. (× 84.)

later date Ribbert (1915) again maintained that the so-called fœtal adenoma arose from embryonic rests. Rienhoff (1929), working with wax reconstructions, has failed to demonstrate these rests and maintains

that interacinar groups of cells are due to tangential cutting of acini. On the other hand, Virchow (1863) held that all adenomatous masses were derived from pre-existing follicles, and Hitzig (1894) and Michaud (1906) agreed with this.

The nature of nodular goitre is another controversial subject. Aschoff (1924) considered all nodules in this type of goitre to be true neoplasms, largely because of their loss of lobulation. Such tumours were considered to arise from normal centrally placed follicles. Hertzler (1928) and Habermel (1934) favoured the view that fœtal adenoma is a true tumour, and Graham (1929) placed nodulation in the category of benign glandular neoplasm. Wegelin (1928), however, believed nodular goitre to be a product of an alternating and differential process of hyperplasia and involution, pointing out the numerous forms intermediate between fœtal adenoma and colloid nodules. Numerous authors, including Marine (1912), Warren (1931), and Delli Bovi (1939) have emphasized the difficulty of differentiating between true tumours and 'hyperplasia involution' nodules.

The solitary nodule, on the other hand, has been studied by Clute and Albright (1936) and Boyd (1938) and considered to be a benign glandular neoplasm.

In the cases under discussion it is difficult to assess the nature of the process. Warren (1931) maintained that in order to place a nodule in the category of true adenoma it must differ in histology from the surrounding tissue and be completely encapsulated. Using these criteria we are justified in regarding the cases described as true adenomata. The fibrosis in the surrounding thyroid tissue suggests that some hyperplastic-involutionary process had been going on, but colloid storage, which is a feature of this process, was completely lacking. In *Cases* 1 and 3 the presence of small seedling nodules consisting of relatively undifferentiated thyroid tissue was observed. These seedling nodules may be regarded either as foci of neoplasia or areas of hyperplasia, according to which view is taken. The important point to be brought out from the study of all these specimens is that the abnormality appears to be in the gland as a whole. Absence of colloid in the surrounding thyroid tissue is confirmatory evidence that we are dealing with a generalized anomaly of the gland, as opposed to a purely local defect which would be cured by local removal.

**Determination of Malignancy.**—The thyroid is well known for the difficulties it presents in the assessment of malignancy. Dunhill (1931) mentioned this, and made the point that all available evidence must be taken into consideration. He stressed in particular the danger of papillary formations. Graham (1924) regarded blood-vessel invasion as the most important single criterion, this feature having been described by Ehrhardt (1902). Graham went so far as to say: "Epithelial tumours that are encapsulated and show no blood-vessel invasion are benign irrespective of their microscopic appearance otherwise", and "Epithelial tumours in which one finds invasion of blood-vessels cannot be regarded as harmless irrespective of their microscopic appearance".

He stated that the pathologist need cut only very few blocks to establish this. It should be mentioned here that artefacts must be ruled out in determining whether blood-vessel invasion has occurred, and it is desirable that the site of invasion of the blood-vessel be demonstrated. Foss (1938)

FIG. 622.—*Case* 3, fifteen months after fourth operation.

quoted Mallory as demanding that a vessel large enough to possess muscularis be penetrated by growth in order to exclude artefacts. In the same paper Foss also described the existence of malignancy even without blood-vessel invasion. The presence of blood-vessel invasion, however, does not mean a hopeless prognosis, as seen in the figures of Lahey, Hare, and Warren (1940). They stated that less than 3 per cent of thyroid adenomata showed vascular invasion and of those that showed it only 10 per cent caused further trouble. Vaux (1937) described intimacy of tumour cells with vascular endothelium of small vessels without actual invasion in malignant adenoma. Other observers take a different approach to the problem. Habermel (1934) gave a guarded prognosis when encountering encapsulated growths with cellular pleomorphism, solid sheets of cells, and mitoses, in the absence of either capsular or vascular invasion. Lange and Maclean (1949) adopted similar criteria, whilst Pemberton (1939) attached great importance to nucleolus–nuclear ratio, this being raised in malignant conditions.

When the cases described are considered from the point of view of possible malignancy, certain features stand out. *Cases* 1 and 2 both showed adenomata of a solid nature and consisted of poorly differentiated thyroid tissue. Nuclear pleomorphism was observed, but mitoses were very scanty. The nodules were well encapsulated with no microscopical evidence of infiltration, nor was there vascular invasion. Intimacy of tumour cells with capillaries was seen, but this feature is so common in thyroid

pathology that it cannot be regarded as a danger sign. In these two cases, papillary formations were not conspicuous, but this feature was seen in *Case* 3. In this case, however, they were not frequent and did not resemble the cellular papillary projections one finds in a true carcinoma of this type. Again in this case there was neither capsular nor vascular invasion. After a careful review of these cases, it is felt that there is no evidence of frank malignancy, using the usual criteria of loss of differentiation, rapid growth, and capsular or blood-vessel invasion. Yet the very cellular appearance of some nodules, with papillary outgrowths in others, would lead some to postulate a low grade of malignancy. Attention should be called to the presence in the surrounding tissue of the numerous small seedling nodules. These are regarded as the precursors of the larger adenomata, and it seems reasonable to assume that the presence of such seedling nodules in thyroid tissue left behind at the time of operation is the source of the recurrences. Aschoff (1924) described the existence of tiny nodules in thyroids in non-goitrous areas, but these very seldom grow in size. It appears that in the cases under discussion there is some stimulus at work which causes undue growth of these nodules such as occurs in goitrous districts.

**Clinical Aspects.**—Certain clinical features appear to stand out from a study of the above cases.

The disease is essentially in the first place one of early childhood, and the enlargement of the thyroid is such as to be obviously diagnosable. There would seem to be no evidence of any geographical feature in the aetiology, but it appears possible that a familial tendency may exist. The actual size of the gland is almost the solitary clinical feature, there being no toxic manifestations and, surprisingly, no pressure symptoms. The increased physiological activity of adolescence would seem to exaggerate the condition and, once established, surgery, and radical surgery at that, appears to be the only satisfactory answer. X-ray therapy has proved of little value and on present-day evidence there would seem small hope of radio-active isotopes effecting much improvement.

It is not suggested that complete thyroidectomy is indicated when surgical intervention first becomes necessary, but the tendency to recurrence, with therefore the possibility of further operations (even to the stage of total ablation of the gland), should be stressed to the parents from the early stages.

Experience with the cases described would suggest that pre-operative thyroid extract is of definite value and it may be that minimal post-operative doses may limit the tendency to recurrence.

**Prognosis.**—Nodular goitres in childhood should always be regarded with suspicion. Kennedy (1940) found 12 cases of carcinoma in his series of 62 cases of nodular goitre in children. That nodular goitre is associated with carcinoma is well known not only in childhood. Carcinoma of the thyroid is more common in goitrous districts, Wegelin (1936) noting that malignant thyroids accounted for 1·04 per cent of all autopsies carried out in Berne. This contrasts with Staemmler's (1914) figure of 0·1 per cent in non-goitrous Berlin. Various figures for the percentages of carcinoma having their origin in adenomatous goitre are Graham (1924) 92·4 per cent, Lahey and others (1940) 80–90 per cent, and Pemberton (1928) 87 per cent. The likelihood of an adenomatous goitre becoming malignant is given in the following figures: Brenizer and McKnight (1940) 4 per cent, and Cole, Slaughter, and Rossiter (1945) 7·2 per cent.

In *Cases* 1 and 2 the ultimate prognosis after the initial recurrences was excellent. *Case* 1 is presumed alive twenty-one years after his last operation and *Case* 2 went for fifteen years before his 1949 recurrence. This particular specimen had a very benign appearance compared with the earlier ones. *Case* 3 must still remain a problem, but as she is left surgically without any thyroid tissue the possible foci for recurrence must be almost non-existent. Absence of vascular invasion seems to rule out future blood-borne metastases.

## SUMMARY

1. Three cases of recurrent adenomata of the thyroid occurred in 2 boys and 1 girl, aged 9, 13, and 13 years respectively. Thyroid swelling had been present for many years in the two latter cases.

2. In no case could frank malignancy be diagnosed using the usually accepted pathological criteria.

3. Attention is called to the abnormality of the gland as a whole in the form of numerous seedling nodules scattered throughout the thyroid tissue.

4. Treatment consists in partial thyroidectomy—repeated if necessary even to the stage of total thyroidectomy. (X-ray therapy appears to have little or no effect on the condition.)

5. Pre-operative thyroid extract is considered of value.

6. Prognosis is regarded as good.

Our thanks are due to Professor W. D. Newcomb for help and advice in the pathological portions of this paper; to Mr. Martin Brett for collecting clinical data; and to Sir Thomas Dunhill, Mr. V. Z. Cope, and Mr. Gordon Bryan for permission to quote details of cases which were originally theirs.

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# SOME OBSERVATIONS ON FRACTURES OF THE NECK OF THE FEMUR

BY JON WALLEY,

ORTHOPÆDIC SURGEON, HIGH WYCOMBE HOSPITALS; FORMERLY FIRST ASSISTANT, ACCIDENT SERVICE, RADCLIFFE INFIRMARY, OXFORD

THIS survey of the results of treatment of fractures of the neck of the femur is based upon the work done by the Accident Service of the Radcliffe Infirmary, Oxford, during the six-year period of September, 1941, to September, 1947. It has been undertaken with the aim of verifying some of the impressions held by practising orthopædic surgeons. Some of the evidence must appear to be incomplete, as must always be the case when case records are compiled without an eye to answering specific questions. It must be borne in mind that these cases were treated during the war years with their shortage of staff and varying surgeons.

The files of the Accident Service record 190 fractures of the femoral neck for this period. On examination of the X-ray films no evidence of fracture was found in 1 case and this case was excluded. Clinical records of 172 were available, the rest being either wholly inadequate or missing. It was not possible to locate the X-ray films of 43 of these cases. Follow-up questionnaires were returned in respect of 130 patients. In only 104 cases were clinical notes, radiographs, and follow-up questionnaires available for survey. It is presumed that random selection has governed the distribution of those cases in which notes, radiographs, and follow-up questionnaires were available.

The average age at the time of fracture for the whole series was 56. The group contained 40 men, whose average age was 54, and 132 women, whose average age was 57. The ratio was thus 1 male to 3·3 females. These figures should be compared with 88 cases of intertrochanteric fracture, in which the average age was 66·5. This range comprised 30 males and 58 females—a ratio of 1 male to 2 females.

## FORMS OF TREATMENT EMPLOYED

| | |
|---|---|
| Reduction and internal fixation by Smith-Petersen pin | 115 |
| Thomas splint and skin traction | 10 |
| Bed rest, with or without anti-rotation boot | 33 |
| Plaster-of-Paris hip spica | 10 |
| Refused any kind of treatment | 4 |

Although this series contains 4 cases of coincident carcinoma (breast, uterus, rectum, and colon—1 case each) there was no evidence to suggest that a pathological fracture was present in the neck of the femur.

## RELATIVE FREQUENCY OF THE SITE

| | *Cases* | *Per cent* |
|---|---|---|
| Capital fracture | 0 | 0 |
| Subcapital adduction | 30 | 23 |
| Transcervical adduction | 65 | 50 |
| Subcapital abduction | 16 | 13 |
| Transcervical abduction | 9 | 7 |
| Basal | 9 | 7 |
| | 129 | 100 |

The obliquity of the fracture line was measured with a translucent protractor by taking the angle between a line connecting the upper and lower limits of the distal fragment, and a line passing through the lower limit drawn parallel to the axis of the shaft of the femur.

*Incidence.*—

| | *Cases* | *Per cent* |
|---|---|---|
| 90°–70° | 25 | 19 |
| 70°–50° | 62 | 48 |
| Less than 50° | 42 | 33 |
| | 129 | 100 |

Pauwels has pointed out that the more vertical the fracture line becomes the worse becomes the prognosis. In this series the fracture obliquity was between 90° and 70° in 25 cases, the details of which are :—

| | | *Cases* |
|---|---|---|
| No follow-up possible | | 6 |
| Sound bony union with good function | | 6 |
| Coincident disease would by itself vitiate function | | 6 |
| Cardiac insufficiency | 1 | |
| Thyrotoxicosis | 1 | |
| Paralysis agitans | 2 | |
| Idiopathic epilepsy | 1 | |
| Death at 3 months | 1 | |

Of the remaining 7 cases :—

| | *Cases* |
|---|---|
| Smith-Petersen pins were removed | 6 |
| Avascular necrosis | 3 |
| Non-union with pseudarthrosis | 4 |
| McMurray osteotomy elsewhere | 1 |

It is sometimes held that fractures of the femoral neck in the youngest age groups have a poor prognosis, as it is considered that the gross trauma required to break the femoral neck in the youngest age groups will also cause associated damage to cartilage and other soft tissues.

## ADDUCTION FRACTURES

*Case* 1.—A boy of 15 sustained at football an impacted subcapital adduction fracture (obliquity less than 50°) associated with a marginal fracture of the acetabulum. He was treated by reduction and a non-weight-bearing plaster-of-Paris hip spica. He walked well at 120 days. On follow-up five years later he is found to be able to run 8 miles and has completed full R.A.F. training.

*Case* 2.—Another youth, aged 18, sustained a transcervical adduction fracture (obliquity 50-70°) impacted in far position. He was treated by a non-weight-bearing plaster-of-Paris hip spica. His intelligence quotient is low but he walked well at 220 days. On follow-up there is painless hip flexion to 80° with ½ in. shortening, and he is doing full work.

*Case* 3.—An undergraduate, aged 23, fell 30 ft. and sustained a transcervical fissure fracture without displacement (obliquity less than 50°). He was treated by a non-weight-bearing plaster hip spica and walked well at 80 days. Eighteen months later, on follow-up, he had a full range of movement of the hip and played all games.

*Case* 4.—In only one case was a subperiosteal fibular peg graft used in conjunction with a Smith-Petersen pin. This was a female, aged 70, who sustained a transcervical adduction fracture (obliquity 70-90°). Post-reduction position, pin position, and impaction were all good, but the fibular graft was short. She walked comfortably at 270 days. The Smith-Petersen pin was slowly extruded and was later removed. On follow-up 6 years after, she had no complaints about her leg and ran a boarding-house.

The general policy, in the main, has been that treatment of fractures of the femoral neck by early Smith-Petersen pin internal fixation is a life-saving procedure, and that the risks of modern anæsthesia are slight enough to allow operative measures to be taken in all but the desperately ill patient.

*Cases* 5 and 6.—In the oldest age group are two females of 88. One, with coincident osteitis deformans, sustained a transcervical adduction fracture (obliquity 70-90°), for which she was treated by bed rest and skin extension. She was discharged home to bed. By contrast, the other case had a subcapital adduction fracture (obliquity 70 90°). This was treated by reduction and Smith-Petersen pin fixation. She was discharged home with a full range of painless movement of the hip-joint and was sitting out of bed, although not bearing weight. She died suddenly from cardiac failure ten weeks after discharge.

*Case* 7.—The oldest patient in which Smith-Petersen pin fixation was performed was a female aged 91 with subcapital adduction fracture (obliquity 70-99°). Post-reduction position, position of the pin, and impaction were satisfactory. She died ten months after discharge and had had a good range of painless hip movement although not bearing weight.

Most authorities would agree that 7–21 days is the optimum time for Smith-Petersen pin fixation.

*Case* 8.—A female, aged 59, sustained a subcapital adduction fracture (obliquity 50-70°) and was treated by traction on a Braun's splint at another hospital. There was no reduction or sign of union at three months. She was transferred to the Radcliffe Infirmary, where reduction and fixation by Smith-Petersen pin was performed. The initial pin was considered to be too short for adequate immobilization and a longer pin was inserted at operation fourteen days later. The fracture united without further incident and the patient walked comfortably in fourteen months from the time of her fracture. There has been no evidence of avascular necrosis. She has now a full range of hip movement and can walk at least one mile without pain.

There are two bilateral cases in this series :—

*Case* 9.—A female, aged 78, had a left intertrochanteric fracture two years before a right transcervical adduction fracture which was treated by Smith-Petersen pin fixation. On follow-up four years later there is no shortening and she states that the legs are equally good, although she wears a bucket calliper following removal of the Smith-Petersen pin (further details were not available).

*Case* 10.—A female, aged 68, sustained a transcervical adduction fracture of the right femur which was treated by Smith-Petersen pin fixation. The leg has given no trouble at all but two years later the left femoral neck was fractured and treated by Smith-Petersen pin fixation at another hospital. The left leg has given much trouble. On further examination there is established non-union, with avascular necrosis of the head, and pseudarthrosis, in the left femoral neck.

## ABDUCTION FRACTURES

These are usually impacted and require no further fixation. Indeed the impression had been that the results of treatment of such fractures by internal fixation have not equalled those treated by conservative measures. In this group are 29 cases (17 per cent) comprising 3 males and 26 females—a ratio of 1 male to 9 females, which is considerably higher than the overall ratio for the series (1 to 3·3).

SITE INCIDENCE FOR ABDUCTION FRACTURES

| | | *per cent* |
|---|---|---|
| Subcapital | 19 | 66 |
| Transcervical | 9 | 31 |
| Basal | 1 | 3 |

**Treatment of Abduction Fractures.—**

*a. Bed Rest* with or without a plaster anti-rotation boot (23 cases).—Average time to comfortable walking 187 days.

*Follow-up* :—

| | |
|---|---|
| Excellent result | 3 |
| Good ,, | 12 |
| Poor ,, | 2 |
| No follow-up possible | 5 |
| Hospital death | 1 |

One of the poor results had severe bilateral coincident osteo-arthritis of hips and knees. The hospital death was from bronchopneumonia (a sequela of rupture of a para-œsophageal abscess).

*b. Plaster-of-Paris Hip Spica* (3 cases).—Average time to walking 190 days.

| | |
|---|---|
| Excellent result | 2 |
| Good ,, | 1 |

*c. Internal Fixation by Smith-Petersen Pin* (3 cases).—Average time to walking 300 days.

| | |
|---|---|
| Fair result | 2 |
| Hospital death | 1 (sequela to pulmonary embolus) |

Although suggestive, it is not possible to condemn the treatment of abduction fractures by Smith-Petersen pin fixation on this small range of cases.

## BASAL FRACTURES

These 9 cases were treated by bed rest with strapping traction in Thomas splint in 6 cases, and by Smith-Petersen pin fixation (no plate used) in 3 cases.

*Follow-up* :—

| | |
|---|---|
| Good result | 6 |
| No follow-up possible | 3 |

Of the good results, 3 each were treated by Smith-Petersen pin and fixation and extension in Thomas splint.

## AVASCULAR NECROSIS

It had been hoped to give some indication as to the most likely period of onset of this complication, but any accurate estimate was impossible owing to the effect of the war years on note-taking and to the fact that most follow-up examinations took place at 3- to 6-month intervals.

The average age of the patient in which avascular necrosis took place was 64·5 (which is higher than the overall age group of the series). It is known definitely that in 25 patients this change took place (14·5 per cent) and this figure must represent the lowest figure for the incidence.

The proportion of males to females is 2 to 23 (1 to 11·5 ratio), which shows a greatly increased incidence when compared with the overall sex incidence (1 to 3·3).

On comparing the figures in

| 1. *Method of Treatment* | | *Overall Figures* | |
|---|---|---|---|
| Smith-Petersen pin | 20 | Smith-Petersen pin | 115 |
| Bed rest extension | 3 | Bed rest | 33 |
| Thomas splint | 2 | Thomas splint | 10 |

| 2. *Impaction* :— | | |
|---|---|---|
| Fair | 12 | |
| Good | 7 | (One radiograph not available.) |

| 3. *Post-reduction Position* :— | | |
|---|---|---|
| Fair | 12 | |
| Good | 11 | (Two radiographs not available.) |

these factors would appear to be of no great significance in the incidence of avascular necrosis.

On examining the relative frequency of the *obliquity* of the fracture line in these cases it is found :—

| | *Per cent* | | *Per cent* |
|---|---|---|---|
| 90°–70° (4) | 18 | General incidence | 19 |
| 70°–50° (13) | 56 | „ „ | 48 |
| Less than 50° (6) | 26 | „ „ | 33 |

The inference from these figures might be that avascular necrosis of the femoral head is relatively commoner in transcervical fractures, but this is not statistically significant.

On inquiry into the effects on avascular necrosis by differing *positions of the pin*, we have :—

| *Cases of Avascular Necrosis* :— | *Per cent* | *Overall Range Per cent* |
|---|---|---|
| Pin short (10) | 50 | 51 |
| Pin up to cortex of head (8) | 40 | 35 |
| Pin penetrating head (2) | 10 | 14 |

Although this is a small range of cases, comparatively, the inference here might be that avascular necrosis of the femoral head is more likely to occur following insertion of a Smith-Petersen pin the tip of which is placed well up to the cortex of the head, possibly by interference with the tenuous blood-supply to a small area of the head via the ligamentum teres.

The Smith-Petersen pin required removal in 13 cases showing avascular necrosis (approximately 50 per cent). Four patients stated on follow-up that their hip was painless and had full function. Six had no shortening and 12 had shortening of 1 in. or more.

As regards function following avascular necrosis—17 out of 25 patients could walk about the house or do better (5 of these wore bucket callipers). The remainder comprised :—

| | |
|---|---|
| Disseminated sclerosis | 1 |
| Hemiplegia | 2 |
| Osteitis deformans | 1 |
| Thyrotoxicosis | 1 |
| Follow-up not possible | 3 |

It is of interest to compare these results with a range of 88 intertrochanteric fractures in which 1 case only of avascular necrosis was found when the patient complained (three years after union of the fracture) that her hip was painful on walking.

*Removal of the Smith-Petersen pin* was performed in 29 out of the 115 cases. In 3 of these cases the pin was considered too short for adequate immobilization and was replaced by a longer one at a later operation. In 10 cases the Smith-Petersen pins were found to be penetrating the head and were removed for that reason.

*In the group of* 29.

| | | *After excluding 10 penetrating Smith-Petersen pins* |
|---|---|---|
| *Site* : | | |
| Subcapital adduction | 8 | 7 |
| Transcervical „ | 15 | 11 |
| Basal | 1 | — |
| *Obliquity* : | | |
| 90°–70° | 7 | 5 |
| 70°–50° | 11 | 8 |
| Less than 50° | 6 | 5 |
| *Post Reduction Position* : | | |
| Good | 10 | 7 |
| Fair | 13 | 11 |
| *Impaction* : | | |
| Good | 6 | 6 |
| Fair | 17 | 12 |

The average interval between insertion and removal of the Smith-Petersen pin was 7½ months.

On inquiry into the 8 cases in which a cross-pin of the Pidcock type through the base of the Smith-Petersen pin was used to prevent extrusion of the pin it was found that :—

2 deaths were due to pulmonary embolism and hyperstatic pneumonia respectively.
1 case now walks 4 miles and ' dances slow '.
1 case no follow-up was possible.
2 cases, the head was penetrated by the Smith-Petersen pin (one of these showed avascular necrosis). Pain in the hip was much improved following Smith-Petersen pin extraction.
1 case, the Smith-Petersen pin and cross-pin were slowly extruded together.

Thus in 3 out of 8 cases the cross-pin either did its function too well or did not do it at all.

*Hospital mortality* for fractures of the femoral neck were 11 in 172—6·4 per cent (*Fig.* 623). Average age 56.

Of the 5 treated by Smith-Petersen pin fixation the distribution was :—

| | |
|---|---|
| Pulmonary embolus | 1 (30 days) |
| Cardiac failure | 1 (18 days) |
| Bronchopneumonia | 2 (both twelfth week) |
| Under pentothal anæsthesia for lumbar puncture | 1 |

(Reason for lumbar puncture is not clear in notes.)

Of the 6 not treated by Smith-Petersen pin fixation the distribution was :—

1 operative death (autopsy showed myeloid leukæmia)
2 bronchopneumonia at 11 and 17 days
1 uræmia at 9 days
1 cardiac failure at 42 days
1 peritonitis – seq. multiple G.S.W.

For comparison 88 cases of intertrochanteric fractures of the femur revealed 10 hospital deaths—

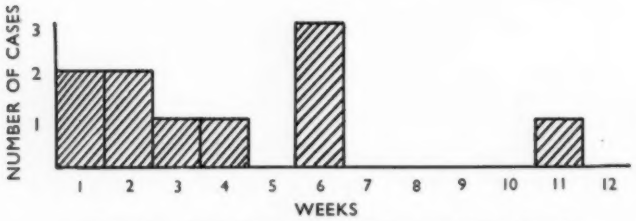


FIG. 623.— Hospital mortality in fractures of femoral neck— 11 cases in 172 (6·4 per cent). Under anæsthesia 2, bronchopneumonia 4, cardiac failure 2, peritonitis (G.S.W.) 1, pulmonary embolus 1, uræmia 1.

11·3 per cent (*Fig.* 624). Average age 66·5. These cases had all been treated by split skin traction in a Thomas splint with Pearson's knee-piece.

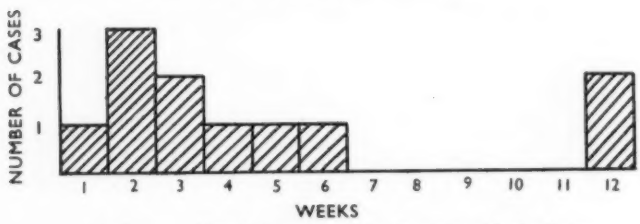


FIG. 624.—Hospital mortality in fractures of the intertrochanteric area—10 cases in 83 (11·3 per cent), bronchopneumonia 3, cardiac failure 3, miliary tubercle 1, pulmonary embolus 1, uræmia 2.

The distribution was :—

| | *Cases* | *Day* |
|---|---|---|
| Bronchopneumonia | 3 | 3, 42, 44 |
| Cardiac failure | 3 | 10, 16, 34 |
| Miliary tubercle | 1 | 7 |
| Pulmonary embolus | 1 | 44 |
| Uræmia | 2 | 11, 70 |

To diverge momentarily, it is interesting to compare American figures on this last point.

Cleveland, Bosworth, and Thompson (*J. Bone Jt Surg.*, 1947) survey 128 cases of intertrochanteric fractures of the femur. Thirty-eight patients, average age 78, treated by traction showed a hospital mortality-rate of 34 per cent. Ninety-five patients, average age 75, were treated by internal fixation with a Jewett pattern pin-plate, with a hospital mortality-rate of 12·6 per cent. From these figures, the writers infer that internal fixation should always be employed as giving a lower mortality and complication rate.

One can only speculate when comparing the disparity of these results with the present series as to the part played by such factors as :—(1) The older U.S. age group. (2) The heavier post-operative morphinization demanded and given in the U.S. (3) The admixture of racial types in the U.S. (4) The commoner use in the U.S. of motor transport and the commoner use in the U.K. of bicycling or walking.

## GENERAL FUNCTION

Males took an average of 226 days to comfortable walking compared with 244 days for females.

*Males*: In 32 cases followed up, treatment was :—

| | |
|---|---|
| Smith-Petersen pin fixation | 24 |
| Plaster-of-Paris spica | 5 |
| Thomas splint | 3 |

These gave the results :—

| | |
|---|---|
| Excellent (walk 6–8 miles, golf, etc.) | 10 |
| Good | 20 |
| Poor | 2 |

Of the 2 poor results one had malaria and a possible prolapsed intervertebral disk and the reason why a Smith-Petersen pinning operation was not performed is obscure. The other, a male aged 76, treated by Smith-Petersen pin fixation, had carcinoma of the rectum, from which he died six months later.

*Females*: Sixty cases in which Smith-Petersen pin fixation was performed gave the following results :—

| | |
|---|---|
| Excellent | 8 |
| Good | 18 |
| Fair | 11 |
| Poor | 23 |

After excluding cases because of

| | |
|---|---|
| Hemiplegia | 4 |
| Disseminated sclerosis | 1 |
| Paralysis agitans | 1 |
| Senile dementia | 2 |
| Paralytic talipes equinovarus | 1 |
| Cardiac insufficiency | 1 |
| Rheumatoid arthritis (advanced) | 1 |
| Bilateral osteo-arthritis of the hip-joints | 2 |
| 'Leg never any use'. (No radiograph available – no follow-up possible) | 1 |

9 cases remain in which there was non-union; of these 2 had diabetes mellitus and 2 had thyrotoxicosis. One had a McMurray type of trochanteric osteotomy elsewhere. The other 4 cases refused reconstructive operation, although one had penetration of the head by the Smith-Petersen pin and another a positive Trendelenburg's sign.

On analysis of the 3 poor results in which radiographs and follow-ups were possible :—

*Site*: Transcervical adduction, 3.
*Obliquity*: 90°–70°, 2; 70°–50°, 1.
*Post-reduction Position*: Good, 1; Fair, 2.
*Pin Position*: Pin short, 2; Pin up to cortex, 1.
*Impaction*: Good, 1; Fair, 2.

The inference from this would appear to be that a transcervical adduction fracture gives the poorest prognosis, although statistically it is doubtful whether this is significant owing to the small range and the preponderance of these fractures in the overall range.

The relative increase of 90–70° obliquity in these poor results is comparatively great when viewed in the light that this group is of the least frequency in the overall range (19 per cent).

Out of 130 follow-up cases it is known that 66 had no coincident disease and no medical complications.

At least 97 could get about the house (some using a bucket calliper) or do better.

Eleven patients stated that the leg was 'no use'.

Twenty-eight patients maintained that the fractured leg was as good as the other.

Seventy cases stated on follow-up that the injured leg was not as good as the other.

At least 31 cases (23·5 per cent) answered that they had no pain, stiffness, or shortening, and no complaints of the injured leg. Pain in the hip and knee was assumed to be an index of degenerative arthritis and occurred in 33 (24 per cent). Shortening noticeable by the patient (and thus presumed to be at least 1 in.) was noted by 35 patients (24 per cent).

| Coincident Disease | | |
|---|---|---|
| Bronchopneumonia | | 3 |
| Cardiac insufficiency | | 10 |
| Carcinoma : | | |
| Uterus | 1 | |
| Breast | 1 | |
| Colon | 1 | 4 |
| Rectum | 1 | |
| Cerebral thrombosis | | 6 |
| Concussion | | 2 |
| Diabetes mellitus | | 6 |
| Disseminated sclerosis | | 1 |
| Epilepsy | | 1 |
| Fat embolism (lungs) | | 2 |
| Fracture associated | | 3 |
| Dislocation | | 2 |
| Malaria | | 1 |
| Osteo-arthritis (hip-joints) | | 4 |
| Poliomyelitis (same leg) | | 3 |
| Paralysis agitans | | 2 |
| Prostatic hypertrophy | | 2 |
| Senile dementia | | 3 |
| Thyrotoxicosis | | 3 |

## SUMMARY

From this range of cases it would appear that :—

1. Men seem to break the neck of the femur at a slightly earlier age, less often, and with a greater chance of good function and walk earlier than women.

2. The transcervical adduction type of fracture is the commonest pattern.

3. Fractures of the femoral neck tend to occur in earlier age groups than fractures of the intertrochanteric region.

4. The commonest angle of obliquity of the fracture seems to lie between 50° and 70°. Fractures in the 90–70° group appear to have a poorer prognosis, as maintained by Pauwels.

5. It seems that in the youngest age group, with correct reduction and immobilization, union occurs without internal fixation or sequelæ.

6. Reduction and insertion of Smith-Petersen pins, combined with good anæsthesia, are well tolerated by the oldest age group of fractures of the femoral neck, and are indeed a life-prolonging measure.

7. Avascular necrosis is commoner in females, and may be commoner in transcervical adduction fractures.

8. Cross-pins, if used, may perform their function too well and may cause penetration of the head in the cases where there is collapse of the femoral neck.

9. The hospital mortality of fractures of the femoral neck is lower than those of the intertrochanteric region. Fractures of the intertrochanteric area treated conservatively in this series have a lower hospital mortality-rate than either of two comparable groups treated in the United States by conservative measures or by internal fixation methods.

I wish to thank Mr. J. C. Scott, Director of the Radcliffe Infirmary Accident Service, for his encouragement and criticism.

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# ACUTE PERFORATION IN REGIONAL ENTERITIS

By J. G. Gow and Anthony Walsh

Royal Southern Hospital, Liverpool

There are many well-recognized ways in which regional enteritis (Crohn's disease) may present. In its acute forms it may simulate appendicitis or appear as an intestinal obstruction : fistulæ are common and an intraperitoneal abscess may rupture, causing local or general peritonitis, as in the case cited by Arnheim and Lee (Arnheim, 1935). Acute perforation of the gut into the general peritoneal cavity is, however, almost unknown, and in his latest publication Crohn (1949) reports no such case. The only such case which we have been able to trace was reported by Halligan and Halligan (1937). Since 1945 we have encountered two further patients with regional enteritis in whom the presenting feature was general peritonitis due to perforation of the intestine. We give here an account of these two cases with a brief summary of the one reported by Halligan and Halligan.

## CASE REPORTS

*Halligan and Halligan's Case* (1937).—A woman, aged 40, who had previously enjoyed excellent health, had a sudden onset of severe generalized abdominal pain. This had been preceded for eighteen hours by pain in the lumbar region of the back. On examination her temperature was 101·4° and her pulse-rate 120. The abdomen was extremely tender all over, with muscle guarding in all areas. Peristalsis was absent, but free fluid was demonstrated. The white blood-count showed 26,000 cells per c.mm., with 92 per cent polymorphonuclears. Laparotomy revealed a severe generalized peritonitis, the abdominal cavity containing turbid free fluid with large flakes of fibrin.

About 2·5 m. from the ileocæcal junction a loop of ileum, 25 cm. in length, showed the classical features of acute regional enteritis. With some difficulty a small, linear perforation was found in the involved loop 0·5 cm. from the mesenteric border. The perforation was sutured and omentum tacked over it. The abdomen was closed with a Penrose drain down to the site of the perforation.

The patient recovered after a very stormy convalescence. Six months later a barium meal showed no evidence of any abnormality.

*Authors' Cases.—*

*Case* 1 (A. W., 1945).—A man, aged 50, while lifting a milk churn was seized with violent central abdominal pain. On admission to hospital four hours later he was shocked and in great distress. He had been perfectly well until the onset of the pain and had suffered no previous illnesses of any consequence. When first seen his temperature was 97°, pulse-rate 120, and blood-pressure 105/65. The abdomen was immobile, quite rigid, and very tender all over ; the tenderness was maximal in the right iliac fossa. On auscultation no peristalsis could be detected. The diagnosis appeared to lie between

acute perforation and acute mesenteric thrombosis. It was thought unlikely that he had perforated a peptic ulcer, as pain and tenderness were most marked in the lower right quadrant.

An intravenous glucose-saline drip was set up and operation was performed two hours after admission.

AT OPERATION (Mr. R. Harvey).—Under general anæsthesia with gas-oxygen-ether the abdomen was opened through a lower right paramedian incision. There was a severe generalized peritonitis, with a large amount of free fluid containing fibrin flakes and small solid particles. About 1 m. proximal to the cæcum a loop of

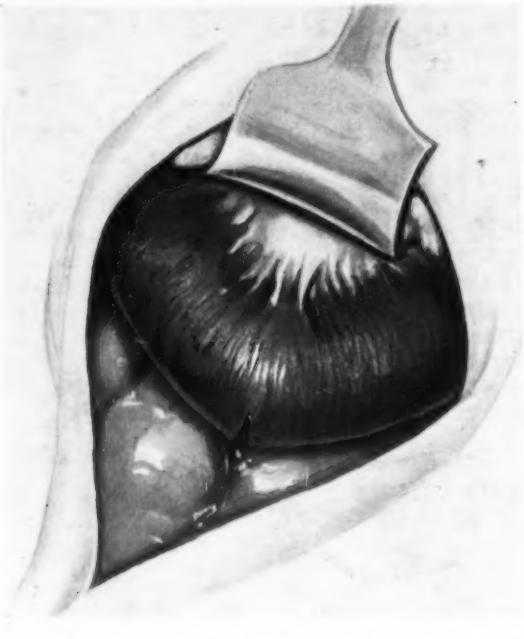

FIG. 625.—*Case* 2. Showing the linear perforation on the antimesenteric border of the œdematous section of small gut.

ileum was intensely reddened and thickened. The affected loop was 20 cm. long, the beginning and ending of the acutely inflamed segment being fairly sharply defined from the relatively normal ileum above and below. The serous coat of the involved loop had several patches of adherent fibrin. The corresponding sector of the mesentery was very œdematous, showing multiple small ecchymotic patches and containing enlarged, matted lymph-glands. The whole picture was typically that of the acute phase of Crohn's disease.

Near the middle of the diseased gut, on its antimesenteric aspect, was a circular perforation, 0·5 cm. in diameter, through which intestinal contents were pouring into the peritoneal cavity. The perforation was sutured with some difficulty owing to the œdema and rigidity of the bowel wall.

Ileotransverse colostomy was considered, but as the condition of the patient was precarious the abdomen was closed with a drain down to the site of the perforation.

PROGRESS.—Post-operatively continuous gastric suction was maintained through a Ryle's tube and the intravenous drip infusion of glucose-saline continued. Two grammes of soluble sulphathiazole were given 4-hourly into the drip. For a few days progress was stormy, but by the fourth day the patient appeared to be improving, although there was some increasing abdominal distension. On the sixth post-operative day there was a sudden deterioration; the patient became very collapsed, presented the signs of a further perforation, and died within two hours.

AT AUTOPSY.—A post-mortem examination performed shortly after death revealed a severe general peritonitis. The loop of ileum which had been involved at the time of operation was now frankly gangrenous and showed a further linear perforation close to the mesentery about 5 cm. from the site of the first perforation. The mesentery of the diseased gut was very œdematous and contained a large matted mass of inflamed lymph-glands. The arteries and veins in contact with this mass showed evidence of recent ante-mortem thrombosis. Presumably this vascular occlusion was the cause of the gangrene and was a terminal event secondary to the gross mesenteric lymphadenitis. Sections of the diseased ileum were made and these showed the characteristic histological picture of Crohn's disease.

*Case* 2 (J. G. G., 1949).—A man, aged 60, walking home after a round of golf, was seized by a sudden excruciating central abdominal pain which was continuous and unrelenting until his admission to hospital five hours later. His previous history was inconclusive; he was said to have suffered recurrent attacks of gastritis, but no radiological examination had been made. During the previous two years he had had intermittent bouts of diarrhœa, the last one accompanied by severe vomiting being ten days prior to his admission to hospital.

ON EXAMINATION.—Despite a prior injection of morphine, ¼ gr., the patient was in great pain, restless, and sweating profusely. The pulse was thin and rapid, and his temperature subnormal. The abdomen was immobile, quite rigid, and acutely tender to palpation, particularly in the left lower quadrant. A provisional diagnosis of perforated diverticulitis was made.

AT OPERATION (Professor C. A. Wells).—Anæsthesia was induced with thiopentone and curare and continued with endotracheal gas-oxygen. The abdomen was opened through a left lower paramedian incision. As soon as the peritoneum was incised a loop of congested œdematous small intestine presented, and in the middle of this loop on the antimesenteric border of the gut a linear perforation, about 2 cm. long, was seen in the transverse axis of the gut (*Fig.* 625). The inflamed loop presented the appearance of acute regional enteritis as described in the previous two cases, terminating about 5 cm. above the cæcum. The mesentery was œdematous and contained some enlarged soft glands. The perforation was closed with mattress catgut sutures. As in the authors' first case an ileotransverse colostomy was considered, but it proved impossible to bring down the transverse colon through the original incision owing to the shortness of the mesocolon. The patient's condition was very poor and it was thought inadvisable to carry out any further procedure, so the wound was closed in layers with drainage. Post-operatively he was given 2 pints of blood intravenously and the drip was continued with glucose-saline. Continuous gastric suction was maintained and penicillin, 250,000 units 4-hourly, was given.

PROGRESS.—The immediate post-operative course was very satisfactory and on the third post-operative day peristaltic sounds were heard on abdominal auscultation and some flatus was passed per rectum. On the morning of the fifth day the bowels were opened, but in the afternoon he had another severe attack of abdominal pain and the abdomen was again found to be rigid and very tender. It was evident that a further perforation had occurred. That evening a second operation was performed (Professor C. A. Wells) and another linear perforation was found about 4 cm. from the original perforation, which, incidentally, showed very little sign of healing. An ileotransverse colostomy with exclusion of the diseased gut was carried out, but the patient died twelve hours later.

## DISCUSSION

A remarkable feature about all three cases is that there were no acute symptoms before the occurrence of the actual perforation, although it seems probable

that in the authors' second case the disease had been present for some time. This particular patient had been having intermittent bouts of diarrhœa for the previous two years, the last one only ten days before the perforation, and no organic disease of the colon was noted at laparotomy. It will be noted also that, as in Halligan's case, the perforations were linear, as, too, was the second perforation in our first case. This corresponds with the known feature that in the second stage of regional enteritis mucosal ulceration predominates, that these ulcers are frequently found to be linear, and that they are situated largely along the mesenteric border of the bowel (Barrington-Ward and Norrish, 1938). It seems likely, therefore, that regional enteritis may be present even in a fairly acute form for some time before any severe symptoms are produced.

As already noted, acute perforation appears to be extremely rare in this disease. This is probably to be explained by the fact that there is a marked tendency to adhesion formation, so that when any ulcer perforates it tends to form a fistula rather than to give rise to a general peritonitis. It seems unlikely that in any case of acute free perforation a correct diagnosis would be made before operation. This is, however, not very important, as the patient's condition is obviously one of acute general peritonitis and immediate laparotomy is indicated in any case. In view of the fact that acute regional enteritis without perforation may give rise to a similar, though perhaps not quite so severe, clinical picture, it is worth while to remember that perforation may occur, as the actual lesion in the gut may not immediately be obvious: in the case reported by Halligan and Halligan (1937) a considerable search was necessary before the perforation was found, although in our two cases it was immediately obvious.

The most important question is to decide what operative procedure should be carried out once the abdomen has been opened and the condition recognized. Although simple suture was successful in the case reported by the Halligans it was not successful in our 2 cases—in one instance because of gangrene and further perforation, and in the second instance because of a further simple perforation. It is significant to note that at the second operation in our second case there was no evidence of any attempt at healing of the first perforation. Garlock and Crohn (1945), in discussing the treatment of 164 cases of Crohn's disease in all stages, stated that in the acute stage primary resection was inadvisable because of the high mortality and the high instance of recurrence of the disease above the level of resection. They came to the very definite conclusion that the treatment of choice was ileocolostomy with exclusion of the distal diseased segment of the ileum, as this procedure gave the lowest immediate mortality and the lowest recurrence rate. We would suggest that this, after suture of the perforation reinforced by an omental covering, is the treatment of choice in any case where perforation has occurred.

We should like to record our grateful thanks to Professor C. A. Wells and Mr. R. Harvey for permission to publish these cases.

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# SUDDEN DEATH CAUSED BY TUMOUR EMBOLUS IN A CHILD OF FOUR YEARS FOLLOWING OPERATIVE REMOVAL OF SUPRARENAL CARCINOMA

By R. McLAREN TODD

SENIOR LECTURER IN CHILD HEALTH, UNIVERSITY OF LIVERPOOL; PÆDIATRICIAN, ALDER HEY CHILDREN'S HOSPITAL, LIVERPOOL

FATAL pulmonary embolism occurs most commonly in elderly patients who are suffering from conditions requiring prolonged rest in bed. This state of inactivity predisposes to thrombosis in the veins of the legs and in 95 per cent of all cases the site of origin of the pulmonary embolus is the deep leg veins (Allan, Linton, and Donaldson, 1945). Evoy (1949) reviewed 1000 reported cases of fatal pulmonary embolism, including 130 that had been under his own care, and he found that the nature of the illness preceding the embolus was "medical" in 43·2 per cent, "surgical" in 48·7 per cent, and associated with trauma in 8·1 per cent. The average age of these patients was 55 years and the medical diseases most commonly associated with the fatal pulmonary embolus were cardiovascular disorders and malignant conditions. Carlotti, Hardy, Linton, and White (1947) consider that pulmonary embolus occurs more commonly in patients suffering from medical diseases than from surgical conditions, and they report 273 examples seen in a 10-year period at Massachusetts General Hospital.

Very few patients in the first two decades have succumbed to pulmonary embolus and the opinion of Holt and McIntosh (1940) that the liberation of large emboli giving rise to sudden shock or systemic symptoms is uncommon in early life is endorsed by the clinical experience of others. Stevenson and Stevenson (1949) reviewed the literature of pulmonary embolus occurring in patients under the age of 15 years from the first reported case in 1861, and they found 30 cases.

In only 2 cases did embolism follow surgical procedures; one of these occurred in a boy of 4

years after rib resection and the other in a girl of 6½ years after appendicectomy. The common preceding illnesses were infections (e.g., mastoiditis, septicæmia, empyema), infectious diseases (e.g., measles, diphtheria), and trauma. The most frequent sources of the emboli were the intracranial sinuses, and the leg veins. From a study of 46,742 autopsy records they found the incidence of fatal pulmonary embolism to be 1·25 per cent in the first decade of life and 1·95 per cent in the second decade. No case of fatal pulmonary embolus caused by tumours was observed in their series.

## CASE REPORT

HISTORY.—E. W., a female child aged 4 years 3 months, was admitted to Alder Hey Children's Hospital for investigation of sexual precocity. At birth a scanty growth of pubic hair was present and during the three months before admission there had been a considerable increase in the amount of pubic hair, which had become darker in colour.

No menstrual bleeding had occurred. One month before admission she had complained of right-sided abdominal pain, and constipation had been severe. There had been no bowel action for four days before admission to hospital.

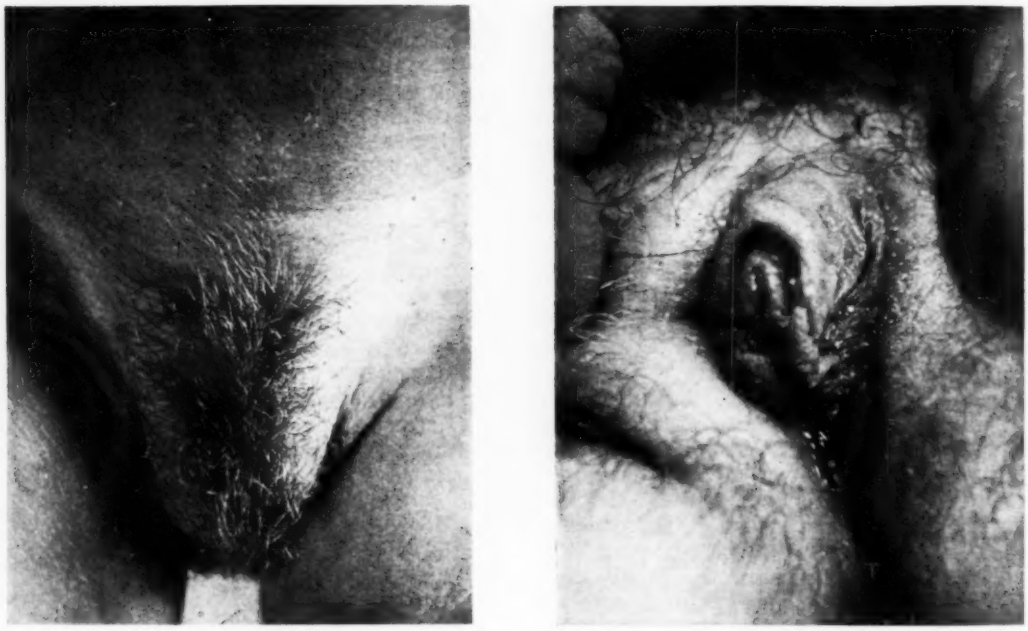

FIG. 626.—External genitalia showing pubic hair and hypertrophied clitoris.

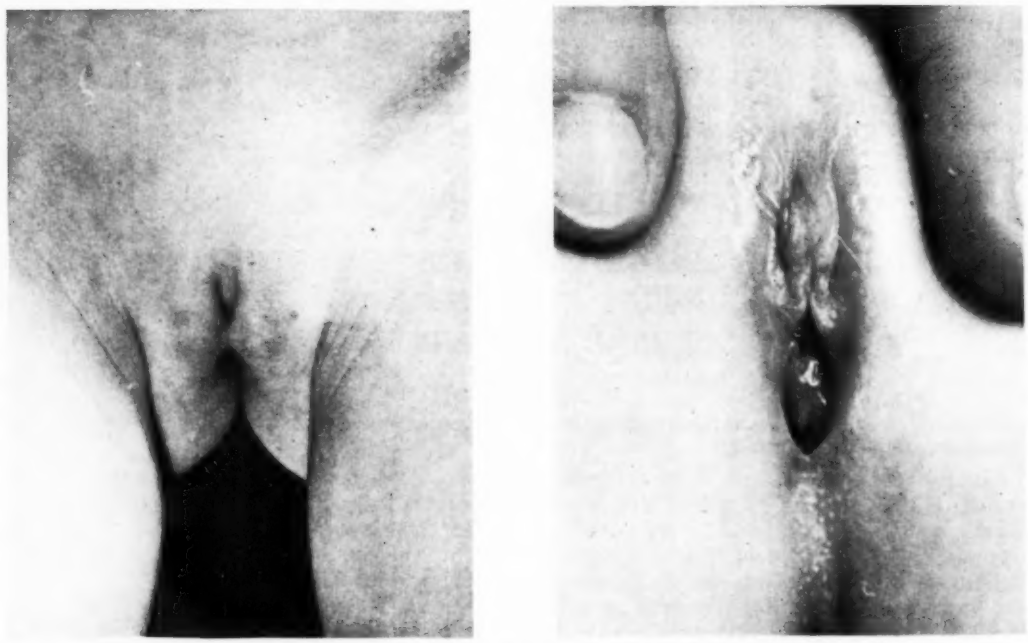

FIG. 627.—External genitalia of a normal child of the same age.

*Family History*.—Mother alive and well. Father had died of carcinoma of stomach six months previously. One sister, aged 8 years, healthy.

ON EXAMINATION.—She was a solemn, uncommunicative child. Her height was 43 in. (normal 39·5 to 42·3 in.), she weighed 42 lb. (normal 32·5 to 41·2 lb.), and her span was 40·25 in. (normal 38.2 to 41.2 in.). Soft downy hair was present on the face, upper lip, and back, there was a profuse growth of dark pubic hair, and the clitoris was hypertrophied (*Figs.* 626, 627). The breasts were not enlarged. No abnormal physical signs were noted in the heart and lungs, but the blood-pressure was raised (145/100). Examination of the fundi revealed no abnormality and there were no abnormal signs in the central nervous system. The abdomen was distended and fæces were palpable. Following an enema the abdomen was still distended, the liver was found to be enlarged, and a mass was palpable in the right loin. No free fluid was present in the peritoneal cavity.

INVESTIGATIONS.—

*Urine*: Routine examination revealed no abnormality.

*Blood-count*: Hb. 80 per cent, 11·7 g. per cent.
W.B.C. 5400 per c.mm.

| | | per cent |
|---|---|---|
| P. | 3564 | 66 |
| L. | 1620 | 30 |
| M. | 162 | 3 |
| E. | 54 | 1 |

Erythrocytes appeared normal.

*Blood-urea*: 33 mg. per cent

*Blood-sugar Curve*:

| | |
|---|---|
| Fasting blood-sugar | 117 mg. per cent |
| ½ h. after 30 g. glucose | 128 mg. per cent |
| 1 h. after 30 g. glucose | 133 mg. per cent |
| 2 h. after 30 g. glucose | 104 mg. per cent |
| 3 h. after 30 g. glucose | 115 mg. per cent |

*Electrolytes*:

| | |
|---|---|
| Serum-sodium | 333 mg. per cent Na |
| Serum-potassium | 20·6 g. per cent K |
| Serum-chloride | 600 mg. per cent NaCl |
| Serum-calcium | 9 mg. per cent Ca |
| Serum inorganic phosphates | 3·6 mg per cent P |
| Serum alkaline phosphatase | 14 units per cent K & A. |

*Hormones*:

Urinary 17-ketosteroids (24-hour specimens) varied from 100 mg. to 251 mg.

Differential 17-ketosteroids (24-hour specimen)
α ketosteroids 85 mg.
β ketosteroids 96 mg.
Ratio α to β 0·9 to 1.

(In normal patients and in hyperplasia of the adrenal cortex the ratio is 9 to 1: in malignant tumours of the adrenal cortex the β-ketosteroids are increased.)

Patterson's test for excess of urinary dehydroisoandrosterone positive.

*Radiography*: Wrists, increased maturation; all bones of the carpus were present. Skull, no abnormality. Chest, no secondary deposits seen. Abdomen, calcification in the area occupied by the tumour.

Intravenous pyelogram: Right kidney shadow displaced downwards but without deformity of the calices.

The diagnosis of malignant tumour of the right suprarenal gland was thus made on clinical and biochemical grounds.

OPERATION.—Miss I. Forshall, assisted by Mr. P. P. Rickham, following anæsthesia with pentothal, gas, oxygen, ether, and tubarine (by Dr. G. J. Rees).—A transverse abdominal incision was made from just above the umbilicus to the right costal margin, through which the presence of a right adrenal gland was verified by palpation. The incision was then extended across the costal margin through the 8th interspace to the inferior angle of the scapula and the diaphragm was split in the line of the incision. A large spherical tumour occupied the left hypochondrium and presented through the stretched peritoneal reflection from the colon to the lateral abdominal wall. The right kidney was displaced downwards and the colon medially. A multitude of engorged veins coursed over the surface of the tumour. The peritoneum was divided and the tumour, which was very soft, almost diffluent in consistency, and difficult to manipulate was separated from the liver and diaphragm above, the kidney below, and the colon medially. Separation from the colon showed the inferior vena cava stretched over the medial surface of the tumour and displaced to the left of the midline. Running from the tumour to the inferior vena cava, above and parallel to the renal vessels, was a short wide vein. When a hæmostat was applied to this vessel it tore and a portion of vein wall came away with a tumour clot about 1¼ inches in length. This clot or thrombus was pinkish-white in colour and soft in consistency. The torn vein, which bled freely, was secured and ligatured. The tumour was then separated from the inferior vena cava and the posterior abdominal wall and removed. Bleeding points were ligatured and the diaphragm repaired. The liver appeared free from metastases but there was a doubtful whitish-yellow patch on the diaphragmatic surface of the right lung. The incision was closed in layers. During the operation, which lasted 2¼ hours, the patient received intravenous glucose saline and blood. The blood-pressure at the end of the operation was 120 systolic and the pulse was of good volume.

FIG. 628.—Macroscopical appearance of suprarenal carcinoma.

Ten minutes after the operation had been completed the child collapsed and the radial pulse could not be felt. Suprarenal extract was given intravenously, oxygen was given by endotracheal tube, adrenaline was injected into the heart and artificial respiration applied. There was no response to these procedures.

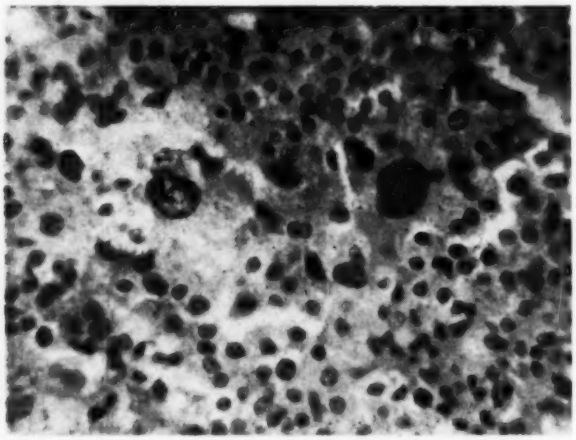

FIG. 629.—Section of tumour, showing general cell pattern and nuclear pleomorphism. (H. and E.) (× 240.)

DESCRIPTION OF THE TUMOUR.—*Gross appearances* (*Fig.* 628). An irregularly spherical tumour weighing 800 g. and measuring 15 × 12 cm. Covering most of the surface is a thin fibrous capsule containing numerous large veins. There are several small nodules of tumour elevating the capsule and in places projecting through it. The tumour is soft and almost cystic in consistency. At one point its contents have been extruded and replaced by gauze.

FIG. 631.—Macroscopical appearances of lungs showing pulmonary arteries plugged with tumour.

The tumour consists of soft fleshy pinkish-white material, in which there are numerous small cysts and clefts. These radiate to the periphery from a necrotic central zone which shows marked granular calcification.

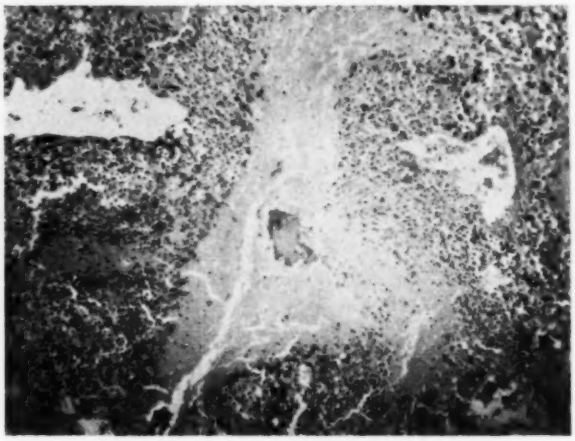

FIG. 630.—Section of tumour, showing area of necrosis with central calcification. (H. and E.) (× 54.)

Similar calcification is present irregularly in the rest of the tumour up to about 1 cm. from the periphery. The peripheral part of the tumour can be flaked very like the scales of an onion.

HISTOLOGICAL EXAMINATION.—In general, the structure resembles that of the adrenal cortex. Individual cells are poorly defined, with a vacuolated or granular pink cytoplasm. Nuclei are heavily stained and show fine chromatin reticulation. They vary considerably in size and shape. Giant nuclei are frequent usually in mononuclear but occasionally in multinucleated cells (*Fig.* 629). Vascular channels are scanty, mitoses are infrequent, there is much necrosis, and decalcification in the necrotic areas is common (*Fig.* 630). Much fat is present. The material gives a strongly positive fuchsinophil reaction. The appearances are those of a malignant tumour of the adrenal cortex.

POST-MORTEM EXAMINATION.—*Heart*: Chambers and valves normal. There was a small amount of clot in the right auricle with one fleck of white material similar to the tumour.

*Lungs*: Right lung collapsed. Both lungs contained numerous nodules of firm white tumour tissue which appeared to infiltrate along vascular septa. Both pulmonary arteries from their sites of division onwards were plugged with firm tumour tissue (*Fig.* 631). There was no evidence of secondary thrombosis.

*Inferior vena cava*: The inferior vena cava had been mobilized where it ran alongside the tumour, and within it there were several fragments of tumour approximately ½ in. below the site of passage through the diaphragm. These were in continuity with plugs of tumour in small vessels leading from the tumour-bed into the vein.

*Liver*: Displaced to the left; no abnormality on section, apart from a small firm hæmorrhagic area ¼ in. in diameter in the left lobe, thought to be an angioma or a metastasis.

*Left adrenal*: Rather smaller than normal, otherwise no abnormality.

*Kidneys*: Both kidneys showed a moderate degree of medullary congestion and cortical pallor.

*Other organs*: Normal.

HISTOLOGY.—

*Left Adrenal*: Normal.

*Retroperitoneal tissue*: No evidence of infiltration.

*Liver*: Tumour metastases, with much necrosis present.

*Material in inferior vena cava*: Similar structure to the primary tumour.

*Lung*: Larger branches of pulmonary artery contain recent embolic tumour fragments (*Fig.* 632). In some of the smaller vessels, the appearances suggest that the emboli occurred prior to those in the larger vessels. Secondary deposits were also present in the lung parenchyma.

*Pituitary*: A striking increase in number of eosinophils was found in the anterior lobe, a feature noted in previous cases of adrenal cortical tumour.

## DISCUSSION

In 1909 Welch wrote that there had been instances of sudden death from blockage of the pulmonary artery by cancerous or sarcomatous emboli; and Dible and Davie (1945) stated that malignant tumours may invade veins of considerable size and the alterations in the wall so caused will set up ordinary thrombosis. Portions of the growth, or of thrombus containing growth, may become detached and swept away to produce the usual mechanical result of an embolus. Willis (1948), in his extensive study of the pathology of tumours, stated that tumour emboli are usually of microscopic size varying from 50 μ to 200 μ in diameter but may be so large as to cause fatal or severe pulmonary embolism, though gross embolism of this kind is rare.

The following case reports of massive tumour embolus of the pulmonary arteries have been recorded in the literature. Judd and Scholl (1924) removed an adenocarcinoma of the kidney from a man of 29 years who died suddenly half an hour after the operation. At autopsy both pulmonary arteries were blocked by soft tumour tissue. Warren (1931) described a man of 32 with chondrosarcoma of the left sacro-iliac synchondrosis who had clinical evidence of small pulmonary metastases and then died rather suddenly. At post-mortem examination the left pulmonary artery was completely occluded by tumour, and some of the branches of the right pulmonary artery were similarly blocked. Warren also referred to a case reported by Ernst of an enchondroma originating in the 12th thoracic vertebra which had invaded the renal and suprarenal veins, the inferior vena cava and left ovarian veins. Masses of tumour were present in both pulmonary arteries at autopsy. Hosoi (1932) described a patient of 59 with a malignant tumour of the ovary who died from a pulmonary tumour embolus; and a patient with a primary malignant endothelioma of the gluteal region in whom many of the smaller branches of the pulmonary artery were occluded by tumour thrombi.

Magee and Magee (1947) described a female patient of 65 years who died suddenly during the second stage of an abdomino-perineal resection for carcinoma of the rectum and at autopsy the pulmonary artery was completely blocked by 3 or 4 worm-like blood-clots. No tumour cells were present in the thrombus and no cause for its occurrence could be found.

Willis (1948) encountered gross embolism of the pulmonary arteries in two of his cases, a woman of 39 years with sarcoma of the thigh and a woman of 47 years with leiomyosarcoma of the uterus.

Mimpress and Birt (1949) reported the sudden death from tumour embolus of a woman of 52 during operation for removal of a right renal tumour.

Pleasants (1911), in a review of 296 recorded cases of obstruction of the inferior vena cava, described 50 cases, including 2 of his own, in which a growth within the lumen of the inferior vena cava had been responsible for the obstruction and in some instances the growth had extended to the right auricle. The sites of the primary tumour, in order of frequency, were kidney, testis, peritoneum, liver, vertebra, pelvis, uterus, and suprarenal. No patients in this series died from tumour emboli of the pulmonary artery.

The possibility of fatal tumour embolus of the pulmonary artery arises when any malignant tumour invades the inferior vena cava or the veins draining

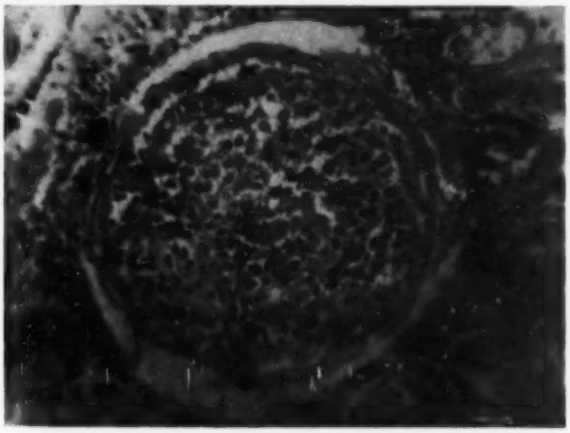

FIG. 632.—Section of lung, showing pulmonary arteriole containing recent tumour embolus. (H. and E.) (× 126.)

into this vessel, but in practice it is rare. More commonly smaller emboli occur and give rise to secondary deposits in the lungs. Masses of malignant tumour cells may be present in the inferior vena cava for considerable periods and they only become detached, giving rise to fatal pulmonary embolus, when local pressure is applied as during an operation.

In the patient reported in this paper the tumour was large, the inferior vena cava was stretched over it, and considerable manipulation was required to free the growth from surrounding structures. Some of the tumour present in the lumen of the inferior vena cava was removed at operation but other portions became detached and caused sudden death by blocking the pulmonary artery.

This appears to be the first reported case of fatal tumour embolus of the pulmonary artery in a child.

I am indebted to Miss Isabella Forshall for the operative details; to Dr. Edward G. Hall for the pathological investigations; and to Professor Norman B. Capon for his advice and encouragement.

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# DERMATOFIBROSARCOMA PROTUBERANS

BY PETER BORRIE, LONDON

THIS condition, first described by Darier and Ferrand in 1924, and given its present name the following year by Hoffman, is a fibrosarcoma which arises in the skin. It is of interest because of its constant and characteristic clinical features, which make diagnosis simple and differentiate it from other soft-tissue sarcomata. However, it is not alluded to in standard British surgical text-books, and of the only two references to it in British medical literature, one (Usher, 1929) describes 2 cases seen in Montreal and the other (Roxburgh, 1947) 1 case which was shown at the dermatological section of the Royal Society of Medicine, but not diagnosed until later. On the other hand many reports appear in the European and American literature, Binkley (1939) collecting 111. The following case report may therefore be of interest.

FIG. 633.—Photograph of moulage of tumour.

## CASE REPORT

HISTORY.—A married man of 52 was seen in the skin out-patient department of St. Mary's Hospital complaining of a lump on his right upper arm. He had always had a flat pink stain in this area—presumably a capillary hæmangioma—but twenty years previously this had become hard, though not raised, and tender. Nothing further was noticed for the next fifteen years, when the overlying skin became minutely wrinkled, and these wrinkles slowly increased to form small nodules.

ON EXAMINATION.—Overlying the right deltoid there was a firm tumour, measuring 4 by 3 in. It was fixed to the overlying skin, but freely movable over the deeper tissues. The colour varied from pink to skin colour, the former being due to the pre-existing hæmangioma, and there were numerous telangiectases coursing over the surface. The whole surface was roughened by pinpoint dimpling, and nodules, well-defined and 0·5 cm. in diameter, could be more easily felt than seen. Halfway down the anterior border there was a depression the size of a pea, and the lower margin was formed by a deeper nodule 5 cm. across (*Fig.* 633). No other abnormality was found. A radiograph of the chest was normal.

TREATMENT.—The tumour was excised, together with ½ in. of surrounding normal skin and the deep fascia, and the wound was closed with a Thiersch graft.

PATHOLOGY.—The specimen had the appearance of a fibrosarcoma of low malignancy, originating at its periphery in the reticular layer of the dermis, but extending into the subcutis in the centre. It was composed of connective tissue, showing areas of well-differentiated collagen arranged in loosely-packed bundles staining pink with Van Gieson's stain. Dispersed between these bundles were more cellular zones, staining yellow with Van Gieson, the constituent cells being very irregular in shape and containing large oval or elongated nuclei having a loose chromatin network and showing an occasional mitotic figure. Fat vacuoles were numerous in the deeper central parts, reticulin was present in the cellular zones and elastic tissue was dispersed throughout the tumour (*Figs.* 634, 635).

## COMMENT

Dermatofibrosarcoma protuberans occurs usually between the ages of 20 and 45, but it has been described in a child of 5. The sexes are equally affected. The abdominal wall and groins are the commonest sites, but the chest, back, and limbs may be involved. The fundamental lesion is a firm, flat, skin-coloured nodule 5 mm. in diameter which, by coalescence with other similar nodules, forms a continuous plaque, usually level with the skin surface, to which it is fixed, though freely movable over the deeper structures. The plaque may remain in this state for anything from five to fifty years, but in time firm sessile or pedunculated tumours grow on the surface, varying in size from a pea to a fist. Once

umour formation begins it continues increasingly rapidly. Ulceration may take place, or the tumours may become soft, necrotic, and hæmorrhagic. Some spontaneously involute and others drop off. The underlying plaque spreads laterally, and much more slowly into the deeper tissues. Finally the whole

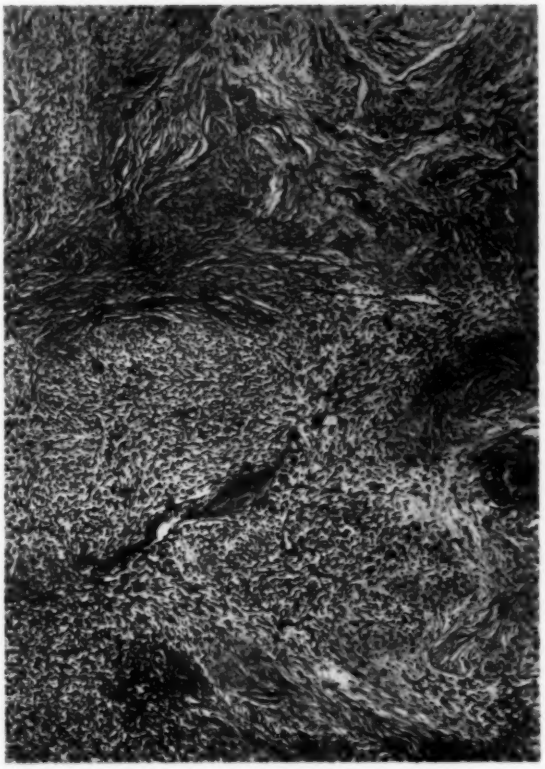

FIG. 634.—Photomicrograph showing both collagenous and cellular areas. (× 50.)

chest, abdomen, and flanks may become covered with the growth.

Metastases are very rare, but have been reported either after the condition has been present for a long time—38 years (Bezecny, 1933) and 50 years (Binkley, 1939)—or after many inadequate local excisions. Fresh centres of growth in the skin also occur, both adjacent to and some distance from the original mass, but they are not thought to be metastatic.

The condition seems to be a different entity from the desmoid tumour or recurrent fibroid of Paget, since the latter is commonest on the abdominal wall of multiparous women, arises from muscle or fascia, and is not thought to be a sarcoma (Stewart and Mouat, 1924). With regard to the latter point, however, Willis (1948) states that there is a complete series of tumours of intermediate structure and behaviour between cellular, anaplastic, highly malignant growths and slowly growing, densely fibrous, benign growths.

## SUMMARY

A case of dermatofibrosarcoma protuberans is described.

This is thought to be a soft-tissue sarcoma arising from the skin and distinct from the desmoid tumour.

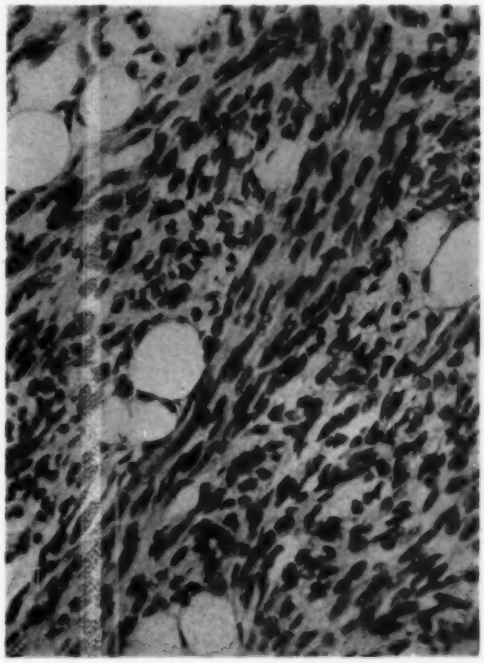

FIG. 635.—Photomicrograph showing irregularly shaped cells infiltrating the subcutaneous fat. (× 280.)

I should like to thank Dr. G. B. Mitchell-Heggs for permission to publish this case.

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# CERVICAL NEUROFIBROMA IN THE DIFFERENTIAL DIAGNOSIS OF CAROTID BODY TUMOUR

By T. H. CULLEN and R. S. MONRO
THE MIDDLESEX HOSPITAL

Among the more rare but interesting swellings encountered in the upper part of the neck are carotid body tumour and solitary neurofibroma. At first sight there would appear no reason for confusing these two tumours, but experience with them has led to the conclusion that their differentiation on clinical grounds may be quite impossible, and a perusal of the literature has revealed that in some quarters these tumours are regarded as being related, an opinion in keeping with the widely held but debatable view that the carotid body is of neural origin. (Marangos, 1939; Goodsitt and Sudimack, 1945.)

Fig. 636.—*Case* 1. Solitary neurinoma of cervical sympathetic chain in a woman aged 40 years.

Whilst the impossibility of clinical differentiation between cervical neurofibroma and carotid body tumour is well illustrated by the two cases of neurofibroma here described, it must be emphasized that these tumours are not pathologically or morphologically related; indeed, the paramount importance of differentiating between them by biopsy must be stressed, since the risks which attach to their operative removal differ so greatly.

The cases here described were nerve-sheath tumours arising from the cervical sympathetic chain. The histological appearance of these growths allowed of their exact description as neurinomata, but the belief that there is no hard and fast difference between the various types of nerve-sheath tumour (Cutler and Gross, 1936; Willis, 1948, a), combined with the convenience of common usage, has led to the adoption of the term neurofibroma to cover all types of nerve-sheath tumour referred to in this paper.*

## CASE REPORTS

*Case* 1 (*Fig.* 636).—N. E., a woman aged 40 years, attended the Middlesex Hospital on April 9, 1948, complaining of a painless lump in the left side of the neck. The lump had been present for five years and had enlarged slowly. She had had increasing deafness for sixteen years. This was due to otosclerosis and there was no evidence to suggest an acoustic nerve tumour.

On Examination.—A firm, pear-shaped tumour was felt in the left anterior triangle, just below the angle of the jaw, pushing forward from beneath the sternomastoid muscle, and displacing what appeared to be the external carotid artery anteriorly. The lump was movable from side to side but not vertically; there was no alteration in the size of the mass on compression; the blood-pressure was 150/80 mm. Hg. Although the findings were not conclusive, a tentative diagnosis of carotid body tumour was made, and the patient was admitted for further investigation and treatment. X-ray of the chest revealed no abnormality; Hb. 100 per cent (Haldane); an electrocardiograph was normal and not affected by pressure over the tumour, and it was decided to explore it.

At Operation (Mr. C. J. B. Murray).—The tumour was approached through a curved incision one inch below the angle of the jaw; it was found lying behind the common carotid artery which it displaced forwards, the bifurcation of the artery being at a high level. The tumour was encapsulated and separated easily from the surrounding structures, except for the sympathetic chain to which it was attached, and a small piece of this structure was

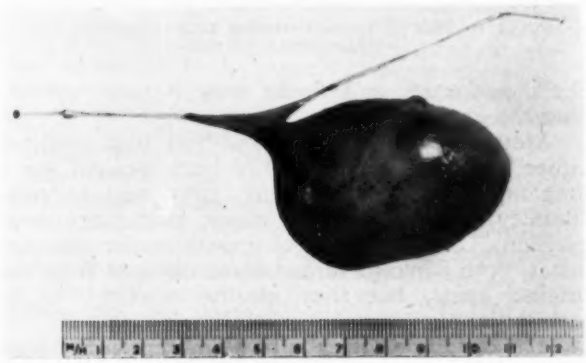

Fig. 637.—*Case* 1. The tumour removed. Attached to it is a short length of sympathetic chain.

* It is realized that this comprehensive use of the term 'neurofibroma' may not be generally acceptable, but after due consideration it has seemed the most satisfactory term to employ, being more concise than 'nerve-sheath tumour', and at the same time sufficiently descriptive for the purpose of this paper, which is primarily concerned with comparing and contrasting such of these tumours as occur in the neck with carotid body tumours, and is not intended to deal with the controversial subject of the relationship of nerve-sheath tumours to one another.

excised with the tumour. Several enlarged soft lymph-glands, which were superficial to the mass were also excised. Save for the development of Horner's syndrome the patient made an uneventful recovery from this operation, and has remained well since. When last seen on May 5, 1950, there was no sign of a recurrence.

THE SPECIMEN (*Fig.* 637).—An encapsulated, ovoid tumour, 6 × 4 × 3 cm., with a nerve skirting it at one end. The cut section revealed a firm, white tissue, with hæmorrhagic areas centrally. Microscopically the appearances were those of a neurinoma, or benign tumour of nerve-sheath origin (*Fig.* 638). The nerve to which the

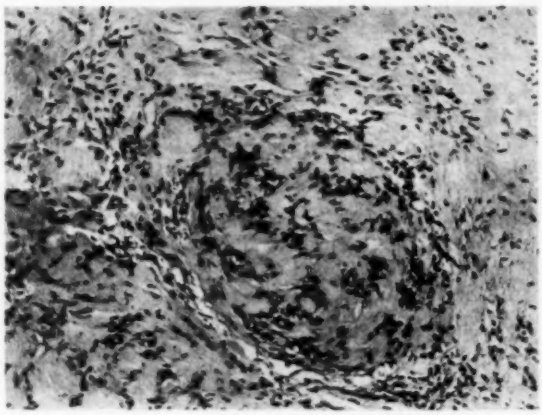

FIG. 638.—*Case* 1. Section of tumour. The whorled arrangement of elongated cells indicates a neurinomatous nature. (× 75.)

tumour was attached contained a sympathetic ganglion. Section of the excised lymph-glands showed simple hyperplasia only.

*Case* 2 (*Fig.* 639).—M. S., a man aged 42 years, attended the Middlesex Hospital on Jan. 23, 1950. He complained of a swelling in the left side of the neck, which he had first noticed a year previously while shaving. The swelling was usually painless, and caused only a feeling of slight discomfort as if there were phlegm in the throat; very occasionally it seemed to be tender and to cause pain radiating into the region of the lower molar teeth. The patient had also noticed that pressure over the lump, as when shaving, caused a feeling of faintness. The swelling had increased gradually in size, showing slight daily variations, usually being larger at night.

ON EXAMINATION.—A mass, approximately 5 cm. in diameter, was found lying below and behind the angle of the jaw on the left side. Laterally it was largely overlapped by the sternomastoid muscle, whilst medially it produced slight bulging of the oropharyngeal wall. The mass appeared to have a slightly varied consistency, in the main firm, but with softer areas, and it was rather imperfectly defined. It was slightly mobile in a horizontal direction, but no vertical movement was possible. There was no pulsation, but firm pressure over the mass gave the impression that it could be considerably reduced in size, and that after such reduction it re-expanded very slowly. A most striking feature was that a main artery, which was thought to be the external carotid, was palpable over the anterior part of the tumour, and pressure over the tumour induced a slowing of the pulse and a feeling of faintness. Apart from a moderate hypertension, with B.P. 180/110 mm. Hg, which had been known to be present for four years, there was no other significant abnormality.

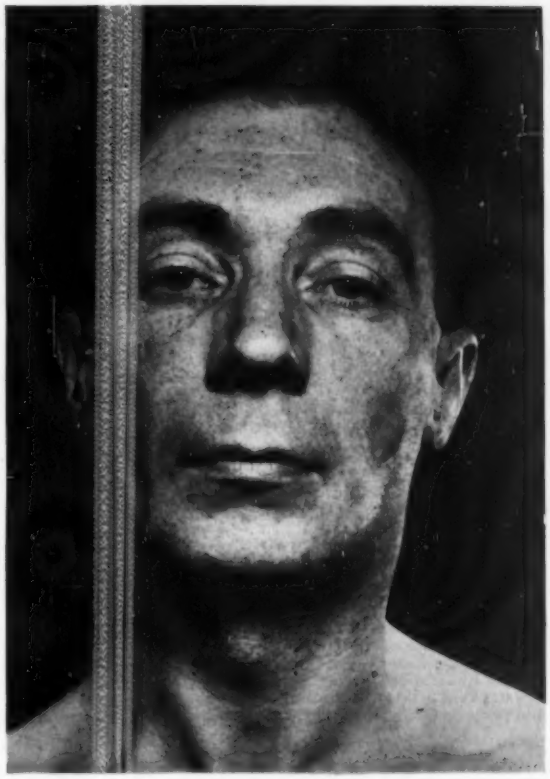

FIG. 639.—*Case* 2. Solitary neurinoma of cervical sympathetic chain in a man aged 42 years.

In view of the situation of the tumour, the presence of a carotid vessel anterior to it, its apparent compressibility (Réclus-Chevassu sign), and its association with an easily elicited carotid sinus syncope, a confident diagnosis of carotid body tumour was made.

Investigations were then undertaken to confirm the diagnosis, to ascertain the nature of the carotid sinus syncope, and to assess the fitness of the patient for operation, with particular regard to the state of the carotid and cerebral circulation in case ligation should prove necessary. Hæmoglobin 103 per cent (Haldane); leucocyte count 5600 per c.mm.; W.R. negative; radiograph of chest, normal; radiograph of neck showed a soft tissue swelling, no abnormal calcification; barium swallow, normal; indirect laryngoscopy, normal; the electrocardiograph showed a simple tachycardia; pressure over

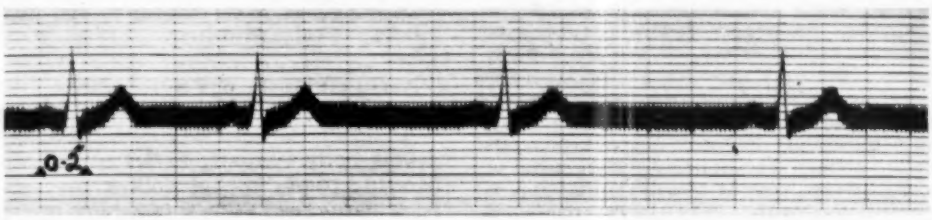


FIG. 640.—*Case* 2. Electrocardiograph showing sinus arrhythmia and bradycardia induced by pressure over the tumour.

the tumour induced a simple bradycardia, i.e., acted by inhibition of the sino-auricular pacemaker (*Fig.* 640); though persistently hyperpietic the blood-pressure showed considerable variation; no secondary arteriosclerotic or adverse cardiac effects were demonstrable. Carotid arteriography was carried out by percutaneous injection. The left side showed some splaying and lateral displacement of the carotid bifurcation and slight compression in this neighbourhood. The left cerebral circulation was

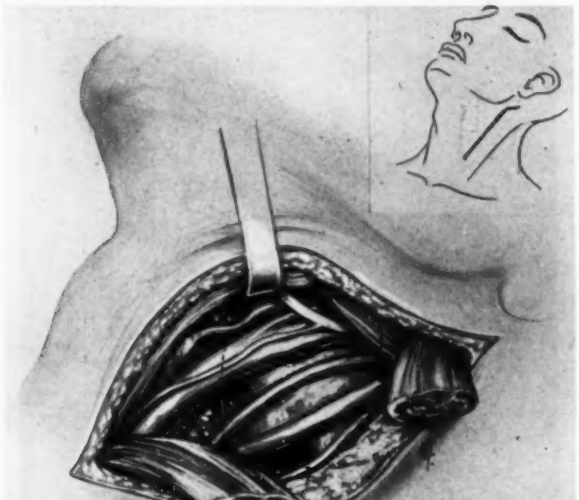

FIG. 641.—*Case* 2. Structures exposed during operation. The sternomastoid muscle has been divided above the point of entry of the accessory nerve. The tumour lies deep to the carotid bifurcation, the vagus nerve, and the compressed internal jugular vein. The upper pole of the tumour disappears beneath the posterior belly of the digastric muscle.

normal. The right side was also injected whilst pressure was maintained on the left common carotid artery and the anastomosis through the anterior communicating vessel of the circle of Willis demonstrated by filling of both anterior cerebral arteries from the right side.

It was decided to explore the tumour and to verify the diagnosis by biopsy, under cyclopropane anæsthesia. If it was confirmed that the mass was a carotid body tumour the intention was to carry out a partial occlusion of the common carotid artery under electro-encephalographic control, and to postpone final removal of the tumour until two weeks later to allow development of the collateral circulation.

OPERATION (R.S.M.).—The tumour was explored through an incision along the anterior border of the sternomastoid muscle, prolonged downwards to give access to the common carotid artery. When the tumour was exposed however (*Fig.* 641), the carotid bifurcation was found to lie across its surface, rather than embracing it, and immediate examination of a portion of the tumour by frozen section technique disclosed neurofibromatous tissue. It therefore appeared so unlikely that removal of the tumour would involve carotid resection, that it was decided to proceed forthwith. The lower pole was approached between the vagus nerve and the common carotid artery and was stripped readily from these structures and from the overlying jugular vein, and equally easily from the prevertebral fascia behind. At the upper pole, however, which reached almost to the base of the skull, and the exposure of which was facilitated by high division of the sternomastoid muscle, the tumour appeared to have a pedicle which passed deeply between vagus and hypoglossal nerves; this was divided between ligatures.

The exact point of origin of the tumour could not be determined with absolute certainty, but it arose posterior and deep to the internal carotid artery, and the patient exhibited a left Horner's syndrome immediately after operation. It was concluded that the tumour arose from the cervical sympathetic chain adjoining the base of the skull. The patient's convalescence was entirely satisfactory.

The tumour removed measured 5 × 4 × 4 cm. It was soft and encapsulated and on section presented a white surface with yellow and cystic areas. Histological examination showed strands of spindle cells with a palisaded or whorled arrangement, the appearances being those of a neurinoma (*Fig.* 642).

## DISCUSSION

Cervical neurofibromata have not infrequently been confused with carotid body tumours. They have been recorded arising from the cervical sympathetic chain as in the 2 cases here described (Mayo and Barber, 1934; Callum, 1949), from the vagus and glossopharyngeal nerves, (Cutler and Gross, 1936; Goodsitt and Sudimack, 1945; Murley, 1948), and from the branches of these nerves to the carotid body (Gordon-Taylor, 1940). Neuro-fibromata have been described as a variety of carotid body tumour, arising from the carotid body itself (Marangos, 1939).

The differentiation of a carotid body tumour from conditions other than cervical neurofibroma is not difficult if such a possibility is borne in mind. Errors in diagnosis have been mainly attributable to the rarity of the condition. By contrast, clinical

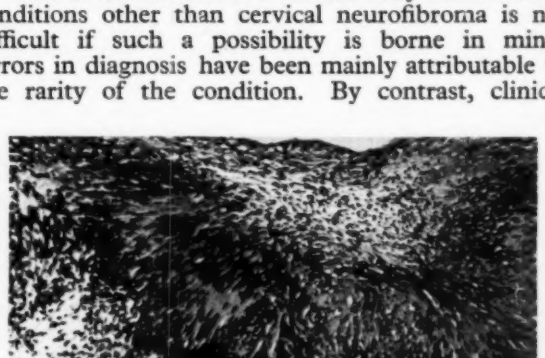

FIG. 642.—*Case* 2. Section of tumour. The palisaded and whorled arrangement of elongated cells typical of a neurinoma is apparent. (× 75.)

differentiation of a carotid body tumour from a neurofibroma may be quite impossible.

In brief the characteristic diagnostic features of carotid body tumour, reviewed at length elsewhere (Monro, 1950), are as follows:—

1. *Situation*: The tumour lies immediately below the angle of the jaw and deep to the sternomastoid at the level of the carotid bifurcation.

2. *Mobility*: The tumour is adherent to the carotid sheath and whilst having a restricted lateral mobility, cannot be moved vertically in the neck.

3. *Relation to great vessels*: The presence of a major artery palpable in front of such a tumour is a feature highly suggestive of a carotid body tumour.

such tumours are usually lodged in the carotid bifurcation, the external carotid artery being anterior.

4. *Réclus-Chevassu sign*: Firm pressure over the tumour may reduce its bulk, which is recovered slowly on release of pressure in a series of pulsations (Réclus and Chevassu, 1903).

5. *Associated carotid sinus syncope*: Sinus syncope in conjunction with a tumour suggests a very intimate relationship between that tumour and the carotid bifurcation, and features in some cases of carotid body tumour.

6. *Associated nerve palsies*: Palsies of the hypoglossal and vagus nerves and of the cervical sympathetic are relatively frequent (Marangos, 1939).

7. *Duration of symptoms*: A history of a tumour which has been slowly growing for a number of years is usual.

A diagnosis of carotid body tumour was made in both the cases here described, and with an unusual degree of assurance in the second instance. Both cases gave a history of considerable duration, and in both the situation of the tumour immediately below the angle of the jaw, its lateral mobility, and the presence of a major artery in front of it gave every indication of its having taken origin from the carotid body. In the second case the diagnosis seemed even more clearly indicated by the apparent compressibility of the tumour, and by its association with attacks of sinus syncope. Nevertheless at operation and on subsequent histological examination both tumours proved to be neurofibromata arising from the cervical sympathetic chain deep to the carotid sheath.

The difficulties attending the differentiation of cervical neurofibroma and carotid body tumour have not hitherto been given adequate emphasis. This is not, however, surprising, for many regard the carotid body itself as having derived from nerve tissue (Willis, 1948, b), many consider its tumours as paragangliomata (Kohn, 1900; Zuckerkandl, 1912), and some hold that the various types of nerve tumour found in the neighbourhood of the carotid bifurcation arise from the carotid body, and see in them an expression of the neural origin of that structure (Mirizzi, 1935; Marangos, 1939).

Such a unitarian concept of pathology leaves no place for differential diagnosis, and gives little encouragement to anticipate differences in operability or prognosis; but it is incorrect. The carotid body is not of nervous origin (Boyd, 1937), and every effort should be made on the one hand to differentiate its tumours from cervical neurofibromata, and on the other to relate such neurofibromata to their nerve of origin; such differentiation is furthermore desirable because of the widely differing risks which attach to the operative removal of the two tumours.

Where on the one hand the removal of a solitary cervical neurofibroma is concerned, the possibility of a dumb-bell extension within the spinal canal must be considered, and excluded by a lateral radiograph of the cervical spine, while if nerve palsies are present the probability of sarcomatous degeneration must be borne in mind. Once these rare complications are excluded, however, it may be anticipated that the removal of a cervical neurofibroma will prove a relatively simple matter.

Where, on the other hand, the removal of a carotid body tumour is concerned, careful pre-operative treatment is required (Monro, 1950); for although in some cases it may prove possible to remove the tumour by simple dissection, in others it may prove necessary to resect the carotid bifurcation, and since the necessity for this step can only be determined by a trial dissection from which no retreat may be possible, it would seem wise, before embarking on any attempt at removal of such a tumour, to carry out a partial or complete preliminary ligation of the common carotid artery.

These in outline are the respective therapeutic procedures best suited to dealing with cervical neurofibroma or carotid body tumour, but appropriate action cannot be taken unless differentiation of these tumours has been possible. Such differentiation may, however, be clinically quite impossible, as the two cases here described illustrate, and in these circumstances it would appear essential to establish the diagnosis by biopsy. If this biopsy is combined with frozen section examination, a differential diagnosis can be made with a considerable degree of certainty and at the earliest opportunity, and it will then be possible to proceed at once either to preliminary arterial ligation if the lesion be a carotid body tumour, or to immediate removal of the tumour, without fear of encountering any undue difficulty, if it be a neurofibroma.

## SUMMARY

Two cases of neurinoma of the cervical sympathetic chain simulating carotid body tumour are reported.

The impossibility of differentiating clinically between cervical nerve-sheath tumour and carotid body tumour, and the importance of making this differentiation by biopsy, is illustrated.

Our thanks are due to Professor P. B. Ascroft and Mr. C. J. B. Murray for permission to publish these cases; to Dr. A. C. Thackray for preparing the microphotographs; and to Mrs. C. G. Trew for the drawing of the field of operation in *Case* 2.

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# ALKALINE PHOSPHATASE IN BREAST CARCINOMAS

By J. M. DRENNAN

RADIOTHERAPY DEPARTMENT, ROYAL INFIRMARY, EDINBURGH, AND PATHOLOGY DEPARTMENT, QUEEN'S UNIVERSITY, BELFAST

THE enzyme alkaline phosphatase is present in the milk (Best and Taylor, 1945) and secreting cells of the lactating breast, and in a proportion of the cells of normal breast epithelium (Dempsey, Bunting, and Wislocki, 1947). Although it thus appears to have the same relation to specialized activity, it has attracted far less attention than the allied enzyme acid phosphatase in the prostate.

The prostatic enzyme has been closely studied owing to its occurrence in carcinomas of the prostate (Gutman, Sproul, and Gutman, 1936), but the possibility of alkaline phosphatase being present in breast carcinomas has scarcely been explored. The sole report on the subject appears to be that of Kabat and Furth (1941), who found alkaline phosphatase absent from four carcinomas of the breast although present in one fibro-adenoma. The present investigation is an extension of this work, designed to show that in a larger series a proportion of breast carcinomas do contain alkaline phosphatase.

FIG. 643.—*Case* 1. Section from a recurrence of breast carcinoma in subcutaneous tissue. (Gomori's reaction for alkaline phosphatase). The tumour tissue is intensely black. Stroma and necrotic areas appear grey or white. (× 10.)

## MATERIALS AND METHODS

Alcohol-fixed sections were prepared from breasts removed at operation and received at the laboratory within a few hours, no fixative having been added. Gomori's method (Kabat and Furth, 1941) was used for the demonstration of the alkaline phosphatase, the incubation time being 12 hours.

*Controls.*—In view of recent criticisms of Gomori's method (Martin and Jacoby, 1949) particular care was taken to check the possible sources of error. These appear to be :—

1. The presence of preformed phosphate in tissues devoid of the enzyme. Since phosphate formation is an intermediate stage in the test (Danielli, 1946) such tissues might give a false positive result. This was guarded against by the use of the conventional control section incubated in a substrate from which phosphoric ester had been omitted.

2. Diffusion of calcium phosphate formed by enzyme activity during incubation in the substrate (Martin and Jacoby, 1949); to detect this, sections from tumours giving a positive result in the routine test were subjected to progressively shortened incubation times until the first tissue to react could be identified. This would necessarily be a genuine reaction.

3. Since false localization would be facilitated by tissue fixation of the diffused calcium phosphate a test was devised to determine the affinity of the various tissue elements for phosphate. Sections from each positive tumour were incubated overnight in a substrate consisting of a 1 per cent solution of sodium phosphate and sodium fluoride, the latter acting as an enzyme inhibitor. Any subsequent reaction with Gomori's reagents could only be due to phosphate fixed by the tissues.

4. The possibility of the enzyme itself diffusing from its true site of localization (Martin and Jacoby, 1949) was controlled by incubating positive sections first in water for one hour, then in Gomori's substrate for half-an-hour, and subsequently comparing them with other sections, incubated in Gomori's substrate (*a*) for half an hour, (*b*) for one hour and a half. Diffusion of the enzyme would then be indicated by an extension of the stained area.

5. A routine section of each tissue stained with hæmatoxylin and eosin was also examined.

The material collected during a period of two years was made up as follows :—

*Carcinomas*, 100 : Undifferentiated 86 (diffuse 41, papillary 18, alveolar 27), adenocarcinoma 7, mucus secreting adenocarcinoma 1, carcinoma occurring during pregnancy 2, carcinoma of the male breast 3, Paget's carcinoma 1.

*Benign tumours*, 9 : Fibro-adenomas 6, duct papillomas 3.

*Cystic mastopathy*, 19.

*Miscellaneous breast conditions*, 6.

## RESULTS

**1. Carcinomas.**—Out of 100 carcinomas of the breast 4 showed the presence of abundant cytoplasmic alkaline phosphatase. In 3 other carcinomas the enzyme was present in localized areas only.

*Case* 1.—A multipara aged 67, suffering also from diabetes mellitus, had a *Stage* 4 carcinoma of the breast with axillary glandular involvement. Treatment was by mastectomy, post-operative irradiation, and excision, nine months later, of a cutaneous recurrence in the treated area.

Histologically the latter proved to be an anaplastic carcinoma with many mitotic figures and scattered small

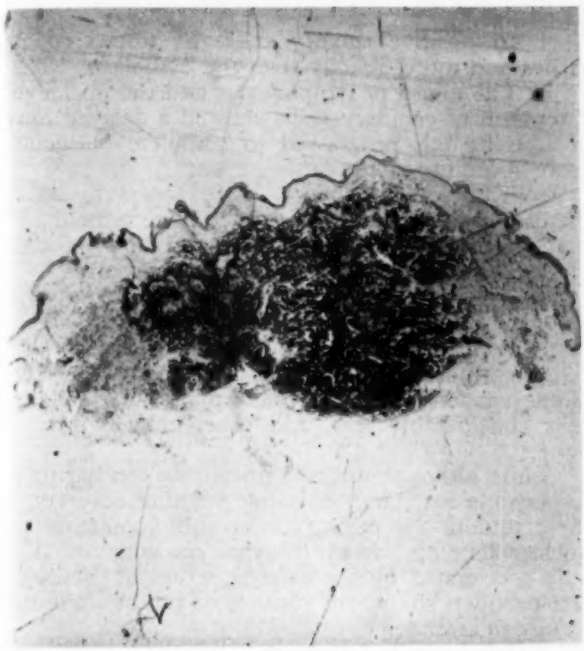

FIG. 644.—*Case* 2. Recurrence of breast carcinoma in subcutaneous tissue (Gomori's method). The tumour tissue is stained black, the stroma is unstained and appears as white lines and spaces. Capillary vessels in surrounding tissue are stained black. (× 10.)

necrotic foci. The patient died some months later; no post-mortem was done.

*Gomori's Reaction* (*Fig.* 643).—In the majority of the tumour cells all cellular detail was obliterated by the intense black staining of a strongly positive reaction. The stroma was diffusely darkened and showed many areas as black as the tumour cells. The few capillaries in the section were also stained black.

*Case* 2.—An unmarried woman of 71 had a *Stage* 4 carcinoma replacing the whole breast, ulcerating through the skin and forming secondary nodules in the skin of the chest wall and axilla. Treatment was by irradiation of the breast and ovaries. A year later the primary tumour, axillary glands, and most of the skin nodules had disappeared and no distant metastases had developed.

In a further nine months, however, numerous skin nodules reappeared, metastases were present in the regional glands and suspected in the spine. The patient died seven months later but no post-mortem was carried out. A subcutaneous nodule about 1·5 cm. in diameter (*Fig.* 644) removed for histological examination showed an undifferentiated carcinoma composed of rather uniform cells arranged in small clumps growing freely in the subcutaneous tissue without giving rise to any appreciable stroma reaction. Gomori's reaction (*Fig.* 645). The reaction was identical with that already described, the tumour cells being all intensely stained. The stroma in this tumour was faintly stained in a diffuse greyish hue deepening to black only at the line of immediate contact with the tumour cells. The normal skin and subcutaneous tissue surrounding the tumour nodule were unstained except for a few small capillary vessels with intensely black walls.

*Case* 3.—A married woman of 62 with a *Stage* 2 carcinoma ulcerating through the skin and involving the axillary glands was treated by mastectomy alone. This patient is still alive four months after operation and is free from metastases or recurrences. A specimen from the breast

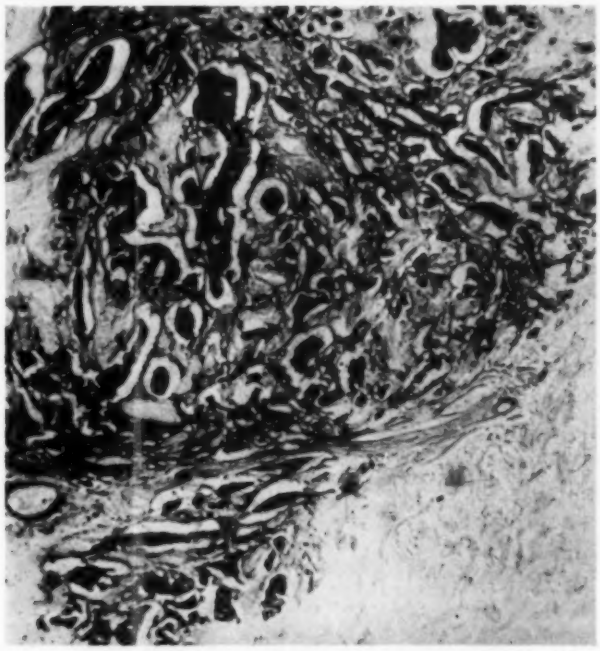

FIG. 645.—Higher-power view of the tumour in FIG. 644 to show the selective staining of tumour cells. (× 100.)

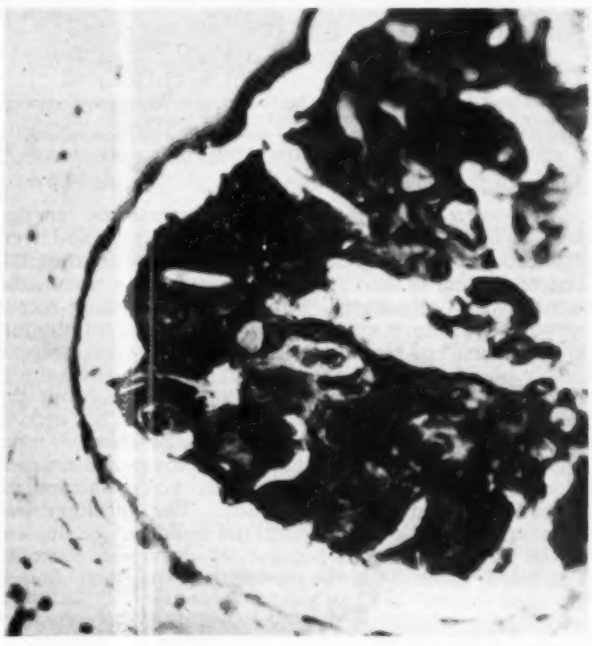

FIG. 646.—*Case* 3. Specimen from the primary carcinoma in the breast. High-power view to show details of staining (Gomori's method). The cytoplasm stains most intensely at the periphery, leaving a paler area in the neighbourhood of the nucleus. The nuclei of lymphocytes and connective tissue cells in the vicinity also stain. (× 400.)

removed at operation showed a highly anaplastic undifferentiated carcinoma with many mitotic figures and patches of necrosis throughout the section. Gomori's reaction (*Fig.* 646), again showed an intensely positive result in the epithelial cells of the tumour. Capillaries

and lymphocytes throughout the stroma were stained black, although the connective tissue itself was feebly stained as in the previous case.

*Case* 4.—A woman of 48 on whom palliative mastectomy was carried out to remove a large fungating breast carcinoma. Death occurred during anæsthesia at a subsequent skin-grafting operation and was considered to be the result of hæmorrhage into retrosternal goitre.

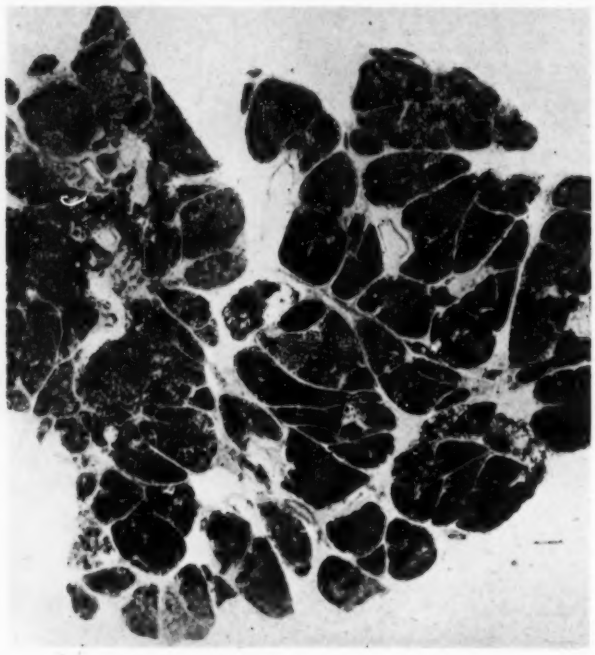

FIG. 647.—Normal lactating breast. A low-power view showing uniform staining throughout the tissue after incubation for half an hour in Gomori's substrate. The clear vesicles represent empty acini. The connective tissue septa are unstained. (× 6.)

*Post-mortem Findings.*—Multiple metastatic carcinomatous deposits in axillary lymph-nodes, lungs, and liver. Extension of the original growth into pectoral muscles. The endocrine system: the patient was very obese, the thyroid was a retrosternal goitrous gland showing recent hæmorrhage into a cyst, there was a persistent thymus with well-marked Hassall's corpuscles and hypertrophy of the lymphoid elements with formation of germinal centres. The adrenal contained abundant adipose tissue but the secretory parenchyma appeared normal. The uterine mucosa was of post-menopausal 'Swiss-cheese' type. The ovaries were not available for microscopical examination but appeared to the naked eye as atrophied, sclerosed, post-menopausal glands. The pituitary was not examined. Gomori's technique could not be applied to the autopsy material because of unsuitable fixation. The biopsy taken from the mastectomy specimen showed the same features as *Case* 3.

**2. Controls.—**

*a. Preformed Phosphate.*—This may be eliminated as a source of error since the control sections were invariably negative.

*b. Reduction of Incubation Period.*—Tumour cells were the first elements to become positive and showed signs of reaction at focal points situated in the periphery of the tumour tissue after only five minutes incubation. Lactating breast epithelium which can be considered as a good positive control was the only other tissue to give a comparable result but differed from the tumour in that the reaction appeared simultaneously throughout the section. (*Fig.* 647.)

The rate of reaction differed in various positive tissues :—

i. In positive tumour cells the nuclei stained earlier and more quickly than the cytoplasm.

ii. The nuclei of lymphocytes and the nuclei and cytoplasm of capillary walls showed a delayed onset of staining but progressed to complete blackening more speedily than any other tissue.

From these experiments there seems to be no doubt that in the most strongly positive tumour cells the Gomori reaction is actually due to the production of alkaline phosphatase by the cells themselves.

*c. Affinity for Phosphate.*—Cell nuclei proved to be the only tissue elements to show any affinity for phosphate. Those of lymphocytes, fat cells, cells in mitosis, and tumour cells giving a positive Gomori reaction took up most phosphate, lactating cells considerably less, and other nuclei little or none.

Thus, although diffused phosphate can hardly be responsible for the cytoplasmic staining observed in these tumours, it might conceivably accentuate the nuclear staining. Many enzyme reactions are similarly accelerated by the catalyst action of their own end-products so that the result need not be attributed wholly to artefact.

*d. Diffusion of Enzyme.*—Since the stained area of tumour tissue in these control sections was never more extensive than would have been expected had they been incubated in the Gomori substrate alone, it may be concluded that the enzyme had not diffused appreciably in watery solution. Alcoholic fixation therefore is effective in retaining the enzyme at its true site.

**Comment.**—The control experiments have minimized the importance of diffusion of end-products as a factor influencing the spread of the reaction beyond the foci at which it first appears in positive tumour tissue. The delayed response of the rest of the tumour is therefore probably due to a lower concentration of the enzyme. In tumours a gradient of functional activity diminishing away from the blood-supply would be expected and it was noted that the reaction always began at foci on the periphery of the tumours where the blood-supply is most adequate. This inherent difference between normal and tumour tissue explains why the tumours failed to show the uniformity of staining observed in lactating breast epithelium.

**3. Benign Tumour Formations in the Breast.**—These included fibro-adenomas, duct papillomas, papillary cystadenomas, papilliferous formations showing the so-called 'sweat-gland' metaplasia, adenosis, and epitheliosis in cystic mastopathy and breast tissue in pregnancy and lactation. It is not intended in the present communication to describe in detail the distribution of alkaline phosphatase in these conditions. The only point that requires emphasis is that the intensity of the reaction appeared to be dependent on the endocrine state of the patient. An epithelial formation which appeared poor in phosphatase when it occurred in post-menopausal patients generally showed abundant enzyme when found in patients of the younger age groups.

## DISCUSSION

The control experiments have shown that the positive Gomori reaction displayed by the cells of certain breast carcinomas is a genuine indication of the presence of alkaline phosphatase.

The significance of this finding remains to be considered. The question at issue is whether the chemical differentiation involved is merely an expression of the genetic inheritance of the tumour cells or whether it has been imposed upon them by hormonal action. If the former, it would be no more noteworthy than the production of alkaline phosphatase by bone sarcomas or of melanase by melanotic carcinomas—in neither case does the capacity for specialized function modify the malignancy of the tumour. Chemical differentiation of the second type, however, has some clinical importance since it may be connected with the susceptibility of the tumour to hormone therapy. The classical example of this phenomenon is the prostatic carcinoma which produces acid phosphatase in response to androgenic stimulation and regresses after administration of œstrogen. The close similarity between breast and prostate in development, histological structure, relation to the endocrine system, and reaction to certain pathological processes, encourages the belief that the alkaline phosphatase-producing tumours of the breast may belong to the same ecological group as the prostatic carcinomas.

Since the carcinomas of this type in the present series have all been obtained from post-menopausal women (one of whom had in addition undergone irradiation castration) the controlling hormone would probably be of pituitary or adrenal, rather than ovarian origin. At this age pituitary-adrenal activity does not normally affect the epithelium of the breast; observations have already been mentioned which show that in the post-menopausal period alkaline phosphatase production fails in normal as well as hyperplastic and benign neoplastic breast epithelium. The appearances of alkaline phosphatase in the carcinomas described may therefore depend not so much on an unusual susceptibility of the tumour cells to hormonal influence, as on an abnormality of the hormonal mechanism itself. Granted these premises, the tumours might respond favourably to sex hormone therapy, since both male and female hormones are capable of depressing pituitary function.

On theoretical grounds also, skeletal metastases should prove to be osteoplastic, as alkaline phosphatase is utilized in the normal process of bone formation. In the cases described there was no radiological evidence of bone secondaries and at the post-mortem on *Case* 4 none were discovered.

The clinical investigation required to provide further information about these tumours will be hampered by scarcity of material. Apart from the infrequent occurrence of the tumours, the histochemical diagnosis is generally made after the breast has been removed at operation. Only subsequent metastases or recurrences will be available for therapeutic testing and except for the rare occurrence of accessible skin deposits it will be impossible to confirm histologically that the enzyme is still being produced. The finding of tumours which contained the enzyme in focal areas alone may be an indication that the ability to produce alkaline phosphatase may vary or be lost.

Up to the present none of the cases in the series have been suitable for further investigation, but the Gomori reaction is being used as a routine procedure on all suitable mastectomy specimens in order that more cases may be collected.

## SUMMARY

1. By the use of the conventional Gomori method, with additional controls to eliminate possible sources of error, it has been shown that abundant alkaline phosphatase was present in the cells of 4 out of a series of 100 breast carcinomas. Small foci of enzyme-containing cells were found in a further 3 carcinomas.

2. Although the main purpose of the investigation was to establish the fact of enzyme production in these tumours, the possible significance of the finding has been discussed with regard to the close general resemblance between breast and prostate. It has been suggested that the presence of alkaline phosphatase may, like that of acid phosphatase in prostatic carcinomas, be a manifestation of hormonal control rather than a mere genetic trait. In this event the tumours may be susceptible to hormone therapy.

3. The difficulties attending the clinical investigation of this point have been mentioned.

4. In support of the idea of hormonal control of enzyme production by the breast epithelium, brief reference has been made to the distribution of alkaline phosphatase in other breast conditions observed during the course of the investigation.

I wish to thank Professor R. McWhirter and Professor J. H. Biggart for their interest and help in the course of this investigation. The post-mortem on *Case* 4 was done by Dr. M. McGeown, who kindly allowed me access to the material. The photography is the work of Mr. David Mehaffey, A.R.P.S., of the Pathological Department, The Queen's University, Belfast. Part of the work was done during the tenure of a Vans Dunlop Scholarship from the University of Edinburgh.

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# A CASE OF HÆMANGIOMATOSIS OF THE SMALL INTESTINE

By P. P. RICKHAM

SENIOR SURGICAL REGISTRAR, ROYAL LIVERPOOL CHILDREN'S HOSPITAL AND ALDER HEY CHILDREN'S HOSPITAL, LIVERPOOL

HÆMANGIOMATOSIS of the small intestine is a rare condition associated with a high mortality. The case described here appears worth recording, because

FIG. 648.—Left hand with a cavernous hæmangioma of the palm.

the diagnosis was made before operation and the patient's post-operative recovery has been most gratifying.

## CASE REPORT

J. W., a boy of 10 years of age, was admitted to Alder Hey Children's Hospital on Oct. 4, 1949. He had a swelling of the palm of the left hand, which had been operated upon three times at other hospitals, but had recurred. For the last two years his general health had slowly but progressively deteriorated. He was listless and easily tired and preferred to sit about instead of playing with other children. At another hospital his anæmia had been treated by a blood transfusion, iron, and vitamin therapy, and while under observation his stools were at times tarry in colour and contained large amounts of altered blood.

ON EXAMINATION.—He was a fairly well-nourished child, not markedly pale. There was an irregular, soft tumour 2½ in. × 1½ in. over the left thenar eminence and the lateral half of the palm of the left hand. The skin over the tumour had a bluish tinge and showed three soundly healed operation scars. The tumour was easily compressible and refilled quickly after the pressure had been released. There was no pulsation (*Fig.* 648). No other abnormalities were noted on physical examination.

*Sigmoidoscopy* was performed on Oct. 17, and the bowel appeared normal for a distance of 20 cm.

X-RAY EXAMINATION.—Radiographs of both hands showed no bony abnormality. A barium meal and a barium enema were both quite normal.

*Blood Examination.*—The hæmoglobin was 48 per cent, and there was marked hypochromasia, some anisocytosis, and poikilocytosis. White blood-corpuscle count was 7300 per c.mm., the platelet count 289,000 per c.mm. bleeding time 1½ min., and clotting time 4 min. The benzidine test for occult blood in the fæces was strongly positive on four examinations.

*A provisional diagnosis* of hæmangiomatosis of the intestine was made, in view of the long history, the absence of any bleeding tendency, the negative X-ray examination and sigmoidoscopy findings and the presence of a cavernous hæmangioma in the left palm.

OPERATION (Oct. 31).—The boy received a blood transfusion of two pints before and one pint during the operation. The abdomen was explored through a right lower paramedian incision. No abnormalities could be seen or palpated in the rectum, colon, spleen, liver, or kidneys. A small tumour was encountered about 3 ft. proximal to the ileocæcal valve, situated in the wall of the gut, near the antimesenteric border; it was of the colour, shape, and size of a small blackberry, embedded in the intestinal wall, and was compressible, refilling after the pressure was released. Two other identical tumours were found, one in the upper ileum and one in the mid-jejunum (*Fig.* 649). The three tumours were excised, together with a thin margin of surrounding healthy bowel wall, and the resulting wounds were closed by suturing transversely with two layers of continuous stitches. There was no appreciable narrowing of the bowel lumen.

POST-OPERATIVE COURSE.—The patient made an uninterrupted recovery. His hæmoglobin rose steadily from 60 per cent to 80 per cent over a period of three weeks and benzidine tests for occult blood in the fæces on four occasions after operation were negative. On Oct. 15, under general anæsthesia, 3 c.c. of 20 per cent saline were injected into the cavernous hæmangioma of the left palm, and in the subsequent week it decreased in size by about

FIG. 649.—Two cavernous hæmangiomata of the ileum photographed at operation.

half. He was discharged on Dec. 1, and has been attending the hospital for follow-up and further concentrated saline injections. When last seen on Jan. 29, 1950, he was extremely well.

PATHOLOGICAL REPORT.—

*Gross Appearance.*—There are three firm tumours, the largest 1 cm. in diameter, lying in the intestinal wall and projecting as irregular sessile masses into the lumen of the gut. All show central depressed areas which are deep

blue in colour. On section of one tumour cavernous spaces filled with blood occupy the mass of the lesion (*Fig.* 650).

*Microscopical Examination.*—The bulk of the tumour is made up of cavernous spaces, walled by an attenuated endothelial lining and fine strands of connective tissue. The lesions lie in the submucosa. There are only a few areas showing recent thrombosis, the majority of spaces containing fluid blood. Internally, the angiomatous tissue is largely limited by the muscularis mucosæ. The depressed areas noticed macroscopically show irregularity and shortening of the villi, with eruption of the angiomatous spaces through the muscularis into the mucosa. At some points the spaces are separated from the lumen of the gut only by epithelium and basement membrane. The capillaries of the villi in these areas are widely dilated and plugged with red cells (*Fig.* 651).

## DISCUSSION

Hæmangiomata of the small intestine are very uncommon. In Raiford's (1932) large series of 11,500 autopsies, tumours of the small intestine accounted for 8·9 per cent of all gastro-intestinal tumours, and benign small-bowel tumours for 5·07 per cent. Six per cent of the benign tumours of small intestine, 3·4 per cent of all tumours of the small intestine, and 0·3 per cent of all gastro-intestinal tumours were hæmangiomata. Hansen (1948), in an authoritative article, states that 66 hæmangiomata of the small bowel have been reported in the literature betweeen 1860 and 1948. Intussusception is a common complication of small-bowel tumours, especially innocent tumours. Intussusception is, however, rarely caused by hæmangiomata of the small intestine (Rankin and Newell, 1933). They are very rarely malignant, only 2 angiosarcomata of ileum having been reported (Kaijser, 1936; Ewing, 1941).

Kaijser classifies hæmangiomata of the small bowel into four types :—

*Type* 1, *Multiple phlebectasia.* There are large numbers of cavernous hæmangiomata of pin-head size which rarely cause symptoms and are usually

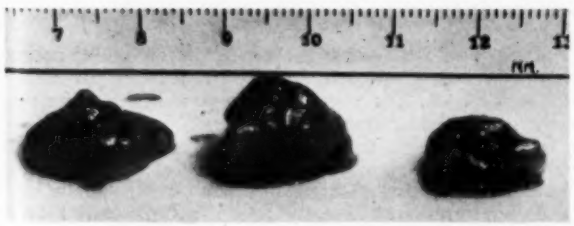

FIG. 650.—The three excised hæmangiomata of the small intestine.

discovered at autopsy. There are 27 cases reported in the literature, 24 males and 3 females, between the ages of 34 and 79 years. Only 4 cases had intestinal bleeding.

*Type* 2, *The single cavernous hæmangioma,* either diffusely infiltrating all layers of the intestine or circumscribed, often polypoid. There are 23 cases reported in the literature, the ages ranging between 15 and 72 years. They were nearly equally common in men and women. Most had severe hæmorrhages. In 3 cases intussusception occurred. There were 6 deaths.

*Type* 3, *Simple capillary hæmangioma.* There were 8 cases, with an equal sex distribution. Two patients had hæmorrhages; 2 intussusceptions, and 4 obstructive symptoms. Seven were operated upon and there was 1 death.

*Type* 4, *Hæmangiomatosis with localization in the gastro-intestinal tract.* Here the intestinal hæmangioma is only an incident in the generalized hæmangiomatosis. There are usually no intestinal symptoms, the small-gut tumours being found at

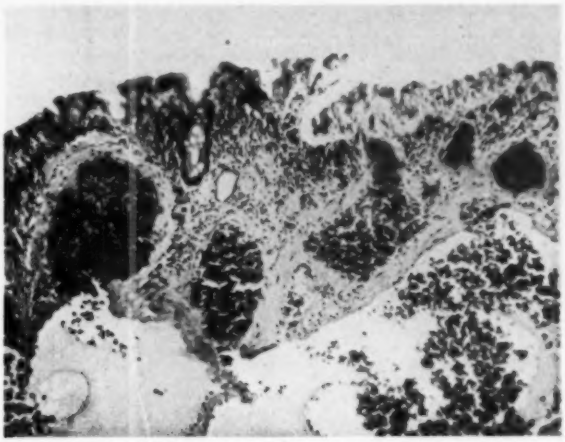

FIG. 651.—Microphotograph of one cavernous hæmangioma of ileum. (× 42·)

autopsy. When symptoms occur they usually take the form of violent, uncontrollable hæmorrhage. The mortality is high in spite of operation. Eight cases have been reported, 3 in males and 5 in females. The ages range between 4 and 81 years. There were 7 deaths, 5 due to hæmorrhage from one of the hæmangiomata. There was 1 recovery after operation. The case reported in this paper belongs to this type.

## SUMMARY

A case of hæmangiomatosis of the small intestine is described. After resection of the hæmangiomata the patient made a very satisfactory recovery. The incidence and the pathological classification of hæmangiomatosis are discussed.

I wish to express my thanks to Miss Isabella Forshall for her helpful advice with the case; and to Dr. Edward G. Hall for the pathological investigations and his report on the sections. Also to Mr. Rodney R. Green for the photographs.

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# SELF-INFLICTED STRIPPING OF THE RECTAL AND COLONIC MUCOUS MEMBRANE

By B. N. CATCHPOLE

DEPARTMENT OF SURGERY, MANCHESTER ROYAL INFIRMARY

THE following case is presented as an example of an unusually severe, self-inflicted, injury.

## CASE REPORT

Mrs. E. T., a chronic epileptic aged 37 years, had her first epileptic attack at the age of 23 years in 1935, after the birth of her second and last child. It coincided with her first menstrual period following delivery.

There is no record available of her progress until 1943. As her epileptic attacks were then increasing in number and occurring regularly at the time of her menses, an artificial menopause was induced by X rays. Unfortunately, however, the effect was only temporary.

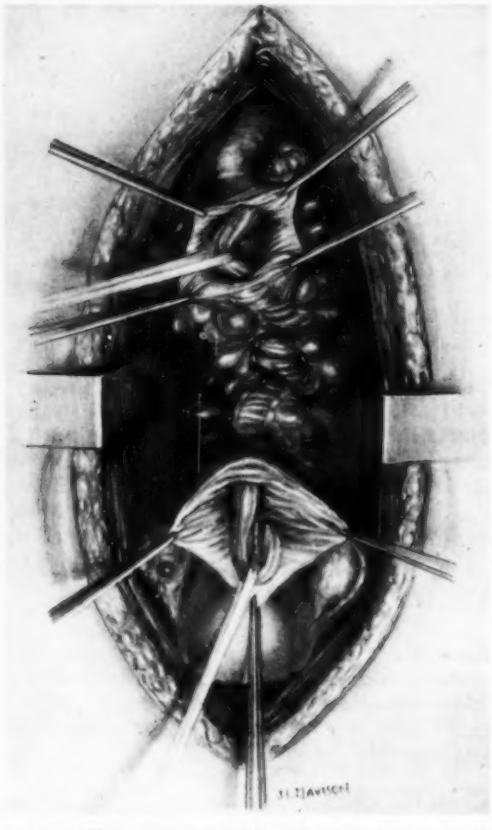

FIG. 652.—The appearance of the affected gut on opening the abdomen.

She was admitted in 1943 as a voluntary patient to a mental hospital, where she was stated to be "a discontented and unco-operative patient". She took her own discharge after one month's treatment.

In April, 1945, she was admitted to the David Lewis Epileptic Colony, Alderley Edge. She continued to have attacks of petit mal at the rate of some thirty per month, but had only three major ones—all in February, 1949. 'Epanutin' was tried without success and her only medication consisted of phenobarbitone gr. 2 daily. Following the minor attacks she was often confused, but had never attempted to damage either herself or others. In between attacks, she did domestic work quite satisfactorily.

At 4 a.m. on the day of admission to the Manchester Royal Infirmary, the patient was found on the floor beside her bed having had an attack of petit mal. She was tearing at her anus and had to be restrained. On examination at that time, she was seen to have a prolapse of mucous membrane of about 3 in. in length. Despite the presence of a nurse, she increased the prolapse, and finally tore it away stating that she had "made a good job of it". She became very shocked but slowly improved, complaining only of a transient backache.

ON ADMISSION.—Her blood-pressure was 110/80 and pulse-rate 100/min., the initial shock having passed off. The abdomen was soft and bowel sounds were present. No free fluid was detected in the abdomen. Two ragged tags of tissue were protruding from the anus, and there was also a slight ooze of blood from the latter. The patient was menstruating and still having attacks of petit mal.

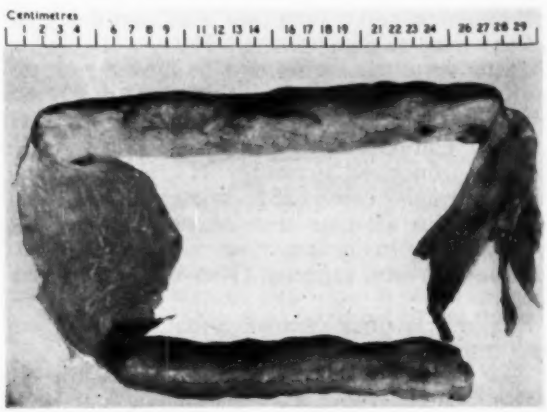


FIG. 653.—The specimen of mucous membrane removed by the patient. It was padded where tubular before being photographed.

A blood transfusion was begun; penicillin and streptomycin were given parenterally.

Eleven hours after initial discovery and three hours after admission she was taken to the operating theatre, where a preliminary sigmoidoscopy was performed. Appendices epiploicæ and a coil of small gut were seen at a depth of 6 in.

She was immediately operated on by Professor A. M. Boyd. Under general anæsthesia, a lower left paramedian incision was made, revealing a sigmoid colon infiltrated with blood and having two ragged tears in the wall (*Fig.* 652). The upper limit of hæmorrhagic infiltration was defined—just below the junction of descending and sigmoid colon. After a towel had been placed over the wound, the rectum and sigmoid colon were removed by the usual perineo-abdominal technique. A terminal colostomy was made in the left iliac fossa. The patient had received three pints of blood during operation and left the theatre in good condition.

PROGRESS.—She proved a difficult patient to nurse; her arms, and later her hands only, had to be bandaged during the greater part of her stay in hospital. On one occasion when the bandages were removed, she was found tearing at the perineal wound. Nevertheless the

continued to improve and was transferred, thirteen days after operation, to the David Lewis Colony.

In the following month she had twelve further minor attacks, but gave no trouble during these.

The original specimen removed by the patient proved to be a length of mucous membrane stripped from the rectum and sigmoid colon. It was completely tubular in two stretches of its length and measured 70 cm. from end to end (*Fig.* 653). The excised specimen shows two complete tears through the seromuscular coat of the sigmoid colon and one through the rectal wall, presumably induced when the forcible stripping of mucous membrane by the patient was done. Running throughout its length there is an unbreached tube of mucosa completely separated from the muscle coat (*Fig.* 654). The smooth postoperative course was probably due, in part, to the absence of fæcal peritoneal contamination. The only soiling of the peritoneum which might have occurred was at the time of sigmoidoscopy, the instrument having been passed along the induced submucous space.

Whilst in hospital, the patient was seen by Professor E. W. Anderson, of the University Department of Psychiatry. She was reported to be in a state of epileptic delirium, with hallucinations and disorientation in both time and space. She became very agitated whilst being interviewed and objected to notes being taken. She admitted, however, hearing the Lord's voice frequently as well as that of Adolf Hitler.

Whilst the prognosis must be extremely guarded, the patient's mental condition may well deteriorate. Interference with her colostomy during any future epileptic attack is likely to bring final disaster.

The specimens were demonstrated to the "Surgical Travellers" during their recent Manchester visit.

My thanks are due to Professor A. M. Boyd for permission to record this case-history; to Professor E. W. Anderson for his examination and help; to Dr. J. M. Kennon for details of the patient's history; and to Miss Davison for the excellent illustrations.

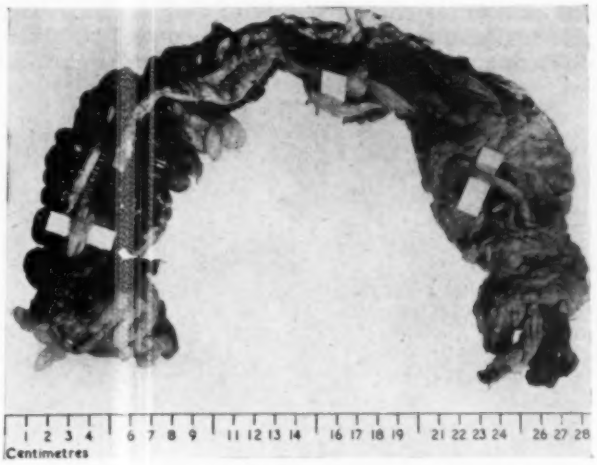


FIG. 654.—The excised specimen of anus, rectum, and sigmoid colon. A fringe of normal colon remains at the extreme left of the specimen; the intact tube of mucous membrane is seen through the tears in the sero-muscular layer, finally protruding through the anus.

# *EXPERIMENTAL SURGERY*

## THE RESPONSE OF THE RENAL CIRCULATION OF THE RABBIT TO ADRENALINE

### AN INQUIRY INTO THE 'TRUETA' SHUNT

BY H. J. BARRIE, G. W. CATES, AND E. A. McCULLOCH*

DEPARTMENT OF PATHOLOGY, UNIVERSITY OF TORONTO

DURING some studies of the blood-vessels of the kidney it seemed important to try and confirm the statement of Trueta and others (1947) that the juxtamedullary glomeruli have a circulation that is functionally independent from that of the outer part of the cortex. According to them, this deep circulation remains when the outer circulation is shut down because of adrenaline injection, stimulation of peripheral or renal nerves, or shock due to limb ischæmia. Some of their best results were obtained by adrenaline injections into rabbits, and as this is such a straightforward procedure (unlike the other three) it seemed the most suitable one for our purpose.

### METHODS

Rabbits were anæsthetized by 1½ gr. pentobarbitonum intravenously. The renal artery and vein on the left side were carefully freed from fat so that they could be watched. The mesenteric artery was then ligated, adrenaline in doses from 2 mg. to 0·05 mg. was given intravenously, and at varying times after this the upper part of the abdominal aorta was clamped, and indian ink (diluted 1 : 2 with saline) immediately injected for two minutes at varying pressures through a needle tied into the lower part of the aorta.

Study of control rabbits and rabbits whose vessels were dilated by caffeine injection showed that the usual pattern of live kidney injections was not much influenced by the operative procedures. Variations in the controls mimicked the changes found when small doses of adrenaline were given and were probably due to adrenaline release. When the injection was finished the hilum was clamped and the whole kidney put into 10 per cent formalin to fix for twenty-four hours. Frozen sections 200–300 microns in thickness were then cut, dehydrated by passing through 85 per cent, 95 per cent, and absolute alcohol, lightly stained with eosin, cleared with methyl salicylate, and mounted in gum dammar.

* Dr. E. A. McCulloch was working with a grant from the National Research Council.

Serial sections were found to be essential in studying the changes, because it was rare that veins and arteries could be followed sufficiently far in any one section for one to be sure of their course. The sections were examined with a high-power binocular dissecting microscope, the most suitable illumination

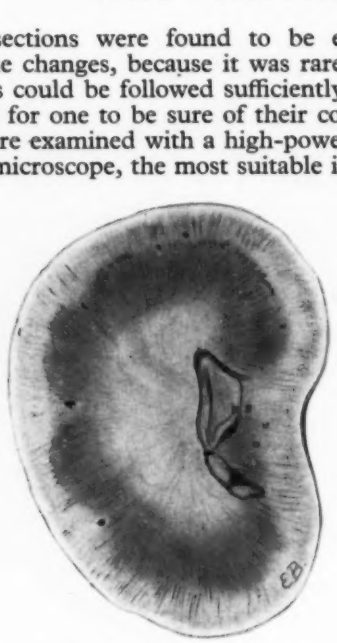

FIG. 655.—Stage of complete circulatory arrest after intravenous adrenaline. Only vestiges of injected ink can be seen in the kidney.

being produced by a lamp mounted over the microscope and reflected back through the section from a piece of white paper mounted under the stage.

The circulatory pattern varied according to the pressure used in injecting the indian ink. As high

FIG. 657.—Microscopical structure of black line in *Fig.* 656. The injected vessels are all veins. The arrow points to the faint outline of an uninjected glomerulus. Cleared section 200 $\mu$ thick. (× 44.)

and low pressure injections each showed something of value they will be described separately.

In the first experiment sixteen rabbits were injected with indian ink at a pressure of 160 mm. Hg. In the second, sixteen rabbits were injected at a pressure of 80 mm. Hg. Six controls were used in each experiment.

**Pattern produced by Injection at 160 mm. Hg Pressure.**—The changes after adrenaline injections followed a definite pattern, which may be divided into three stages: (1) Complete circulatory arrest; (2) Venous reflux; (3) Lobular escape. High doses were necessary to cause any of these changes. When two minutes elapsed between adrenaline and ink injection, 1 mg. of adrenaline was necessary to cause complete circulatory arrest. If the time between injections was increased, the

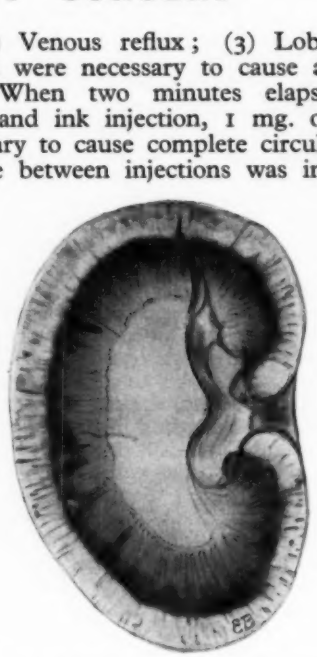

FIG. 656.—Stage of venous reflux after intravenous adrenaline. The dark line is caused by ink in the veins.

other two stages were successively encountered. If ink injection was made immediately after the adrenaline, 0·2 mg. of the latter was sufficient to produce the phase of venous reflux and 0·1 mg. the phase of lobular escape. These doses are average ones, for they varied slightly from rabbit to rabbit. These stages may be discussed briefly.

*Complete Circulatory Arrest.*—In this stage, no indian ink enters the kidney, which therefore appears quite pale (*Fig.* 655). This is a well-recognized response to high doses of adrenaline and is caused by arterial contraction. In many rabbits there was also segmental or complete contraction of the main renal vein.

*Venous Reflux.*—This stage is illustrated in *Fig.* 656 and, as can be imagined, we at first thought that we had produced a 'Trueta' shunt. When the cleared sections were examined, however (*Fig.* 657), the black zone was found to be due to ink in the veins in the arcuate line and in their tributaries coming from the medulla and deep part of the intertubular plexus. Occasional glomeruli had been filled retrogradely via efferent vessels that supplied the intertubular plexus, but the arteries and the afferent arterioles were empty. It seemed quite clear that the medullary and intertubular venous channels were being filled from the main arcuate veins by retrograde extension, and we found that we could increase the width of the resultant black zone by increasing the pressure with which the indian ink was injected. The reason for this venous reflux will be dealt with in the discussion, but the fact that it occurs is of great importance in interpreting the naked-eye appearance of injected kidneys.

*Stage of Lobular Escape.*—It seemed reasonable to assume that after spasm of the renal arteries, the latter might progressively dilate in a distalward direction, and provide the juxtamedullary glomeruli with a blood-flow earlier than the cortical one. We

never saw this happen, and if it occurs it must be very transient. Escape from spasm affects individual units as a whole, so that lobular escape occurs, and in that area the whole cortex and medulla is flooded with ink (*Fig.* 658). These areas of injection increase and finally the whole kidney resembles the controls.

FIG. 658.—Stage of lobular escape. Individual lobular arteries have opened up through full depth of cortex.

**Pattern produced by Injection at 80 mm. Hg Pressure.**—As in the previous experiment, the immediate result of adrenaline injection was complete shut-down of all the arteries of the kidney except the arcuate arteries (*Fig.* 659), and this lasted for about 30 seconds. This spasm did not affect the

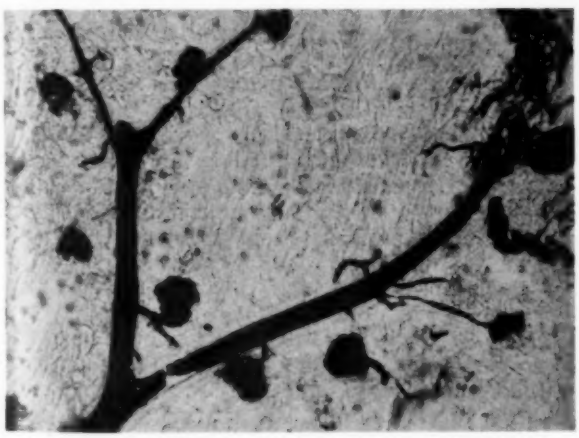

FIG. 660.—Low-pressure ink injection. First stage of relaxation in main part of cortex. Vasoconstriction persists at level of efferents.

small arteries of the pelvis and renal sinus, which were easily injectable with ink. Blood and not ink was present at this stage in the veins of cortex and medulla. With the passage of time there was progressive opening up of the arterial circulation, but in a fairly constant sequence. Owing to 'lobular escape' the fields of supply of the lobular arteries were in different stages at any one time, but each opened up in the same order and in a manner suggesting the presence of standard sites of vascular contraction.

The first stage of relaxation, beginning 30 seconds after the injection of adrenaline, let the ink right through as far as the efferent arterioles, so that the glomeruli on their afferents stood out against the empty capillary bed like grapes on a vine (*Fig.* 660). In the juxtamedullary glomeruli, however, this hold-up at the efferent arterioles was lacking, so that

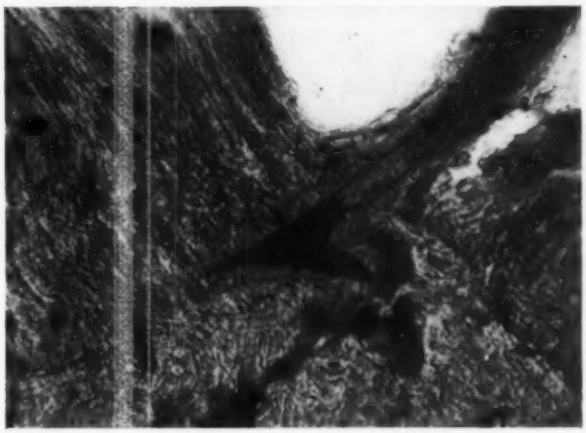

FIG. 659.—Immediate response to adrenaline. Shut-down of all lobular arteries.

the ink filled the long efferents. Their short side branches supplying the convoluted tubules were closed and this rendered them very conspicuous and 'bare' (*Fig.* 661). At first sight again this seemed to be a proof of the cortical by-pass described by Trueta. Close inspection, however, showed that

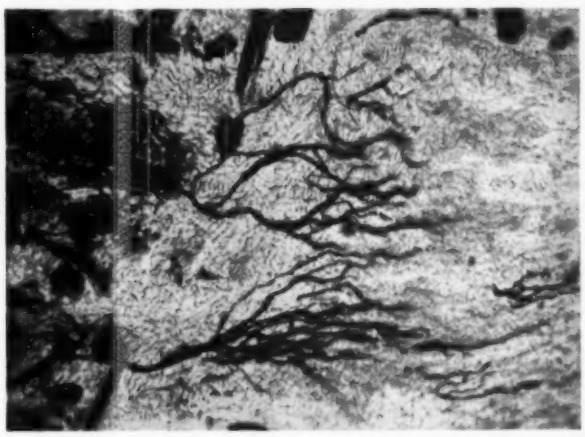

FIG. 661.—Low-pressure ink injection. First stage of relaxation in juxtamedullary zone. The veins are not being filled.

there was no actual circulation through the medulla and that there was a shut-down at the terminations of the long efferents, as shown by complete absence of ink in the venous component of the vascular striæ and in the arcuate veins. This can be seen by comparing *Fig.* 661 with *Fig.* 662, in which the veins are full of ink.

The next stage occurred about two minutes after the adrenaline injection, when the efferent arterioles of the main part of the cortex relaxed and ink flooded the capillaries and their venous drainage bed. The

arcuate vein contained ink. This had come from the cortical veins because the long efferents were still 'bare' and the venous component of the vascular striæ still empty of ink and full of blood. A little venous reflux into the capillaries of the medulla now occurred.

Finally, there was reversion to the normal injection pattern occurring not earlier than three minutes after injections. Throughout the stages of relaxation the immediate subcapsular zone lagged behind the rest of the cortex, so that the colour of the capsule offered little information as to what was happening

FIG. 662.—Appearance of veins when full of ink, to contrast with *Fig.* 661. Taken from same section as *Fig.* 657.

in the rest of the cortex. This might of course have been due to the fact that the capsular arteries were not being injected, but in observations without ink injection the subcapsular zone was seen to stay pale longer than the rest of the cortex.

We conclude that relaxation from vascular spasm occurred in the following sequence :—

1. Relaxation of the blood-vessels of the main part of the cortex as far as the efferent arteriole and of the vessels of the juxtamedullary glomeruli as far as the termination of the long efferents.
2. Relaxation of the efferent arteriole and capillary bed of the main part of the cortex.
3. Relaxation of the side branches of the long efferents.
4. Relaxation of the termination of the juxtamedullary efferents and of subcapsular capillary bed.

## DISCUSSION

Injection of ink under high pressure accentuated the changes in the larger vessels, and injection under low pressure brought out the changes in the smaller vessels. The phenomenon of venous reflux merits a little discussion. The ease with which the venous side of the kidney can be filled by arterial injection has been known for a long time. Steinach (1884) thought that this phenomenon had caused many authors to mistake the medullary veins for arteries. There are broad anastomoses between the renal veins in the renal sinus and in the arcuate lines, so that material gaining access to any vein can rapidly fill the whole system. The venous reflux which was so prominent a feature in the first experiment, but only mild in the second one, could have been due to rupture of arteries into veins, arteriovenous anastomoses, or to a collateral circulation.

We do not think arteriovenous rupture was probable, for there was no other evidence of arterial rupture, such as interstitial pools of ink, and the results were too constant.

Barrie, Klebanoff, and Cates (1950) described arteriovenous anastomoses in the arcuate line, and it was tempting to incriminate them, but we found no evidence that such a shunt was responsible. The most likely source of the blood, in our opinion, was the renal sinus, the rich circulation of which is not affected by adrenaline and could easily gain access to renal veins.

It is important therefore to stress that the presence of increased amounts of blood or radio-opaque substance in any part of the capillary or venous bed does not mean that there must be an increased circulation through it. Widely dilated vessels more often signify a reduced circulation than an increased one.

We were, therefore, not able to confirm that adrenaline causes the changes in the renal circulation described by Trueta, Barclay, Daniel, Franklin, and Prichard (1947).

It may be objected that the doses of adrenaline administered were unphysiological. To that we say that results of lesser doses have no effect that is demonstrable by this technique. This would be slender evidence on which to assert that an independent deep cortical circulation does not exist, but we are led to examine the positive evidence a little more closely. As anyone who has had experience of injecting the kidney will know, the results are often hard to interpret from single microscopical fields, and it is therefore rather graceless to base criticisms on published illustrations. It seems to us, however, that some of the figures in *Studies of the Renal Circulation* might have another explanation than the one which is credited to them.

*Figs.* 18, 23 a, and 29 are held to illustrate the operation of a deep cortical circulation, but we think that they could equally well represent the stage of venous reflux. The injected zones are wide, which, to us, would presuppose a high injection pressure. According to the legend, the injections were made into the renal artery. From practical experience with the rabbit we assume that this was done with a syringe and needle, and with this technique injection pressures may be deceptively high.

Bismuth was used as an injection by Trueta and co-workers in some of their experiments, and *Figs.* 21 and 71 show its unsuitability for judging circulatory channels in the kidney, for it can be seen quite clearly that it was not getting through the glomeruli at all. The injection of glomerular efferents, with their generous spray of branches into the medulla, produces an unmistakable picture when present (*see Fig.* 661).

More evidence cited was the effect of staphylococcal toxin. Use of this agent to produce functional changes in circulatory pattern seems a little drastic, for it produces rapid cortical necrosis. De Navasquez (1938) described this necrosis as being preceded by necrosis of the lobular arteries. The character of the toxins of staphylococci varies widely according to the strain of organism used, and one strain supplied to us by Dr. R. J. Wilson produced tubular but not vascular necrosis. The circulatory pattern in the kidney as shown by indian ink injection remained

normal until the third day after administration of toxin. We feel that the sentence on page 109 of *Studies on the Renal Circulation*, reading, "We had thus produced a cortical ischæmia of such a degree that it resulted in a cortical necrosis", is misleading in it implies a reflex arterial response. As the liver was equally resistant to injection and was necrotic, we suspect that the sentence might with greater conviction be rendered, "We had thus produced cortical necrosis of such a degree that it resulted in cortical ischæmia".

The few published attempts to demonstrate the 'Trueta' shunt have not been successful. Moyer, Conn, Markley, and Schmidt (1950) found that sciatic nerve stimulation gave no change in the circulatory pattern that could be demonstrated by indian ink injections, and found that 0·02 mg. of epinephrine produced only transient local effects. This transient effect seems to have been the stage of venous reflux. They also found no decrease in the oxygen content of arteries and veins after sciatic nerve stimulation or epinephrine administration. Goodwin, Sloan, and Scott (1949), using limb tourniquets and central and peripheral nerve stimulation in various animals, found no direct evidence for a 'Trueta' shunt.

We feel that from what injections can show, there is little evidence for the presence of an independent deep cortical circulation.

## SUMMARY

1. *In vivo* injections of indian ink were made into rabbit kidneys at varying times after giving adrenaline into the ear vein.

2. The immediate result of adrenaline was complete shut-down of the renal circulation.

3. In the phase of relaxation of vasospasm there was temporary hold-up of the ink at the beginning of the efferents in the main part of the cortex and at the end of the efferents of the juxtamedullary glomeruli.

4. The lobular arteries did not relax synchronously.

5. When ink was injected at high pressure, the first change in the circulatory pattern after the phase of complete constriction was a flooding of the medullary region with ink. This was due to 'venous reflux' and not to increased circulation through the juxtamedullary arterioles.

6. We found no evidence that there is a phase of independent circulation through the juxtamedullary glomeruli.

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# *SHORT NOTES OF RARE OR OBSCURE CASES*

## RUPTURED SPLENIC ARTERIAL ANEURYSM

BY R. E. B. TAGART, CAMBRIDGE

RUPTURE of a splenic arterial aneurysm is a rare occurrence and almost invariably fatal. A single case is reported here since the patient was fortunate enough to survive, and the opportunity is taken briefly to review the literature on the subject.

Sherlock and Learmonth (1942) reviewed 125 cases of splenic aneurysm collected from the literature, while Tonge (1948) was able to find reports of 145. Since then, 1 further case, a fatal rupture in a pregnant woman, has been reported (Sheehan and Falkiner, 1948).

**Pathology.**—The commonest cause of splenic aneurysm is atheromatous degeneration of the artery, 46 per cent of the patients in Sherlock and Learmonth's series suffering from this: 23 per cent of their cases were due to embolism, while the less common causes are congenital arterial defect, trauma, ulcer or cancer of the stomach, portal hypertension (Banti's syndrome), syphilis, malaria, arteriovenous aneurysm, wandering spleen, splenic arterial thrombosis, and Gaucher's splenomegaly.

The sex distribution is approximately equal but a surprisingly high proportion of the women affected have been in the later stages of pregnancy, 25 per cent in Cosgrove, Watts, and Kaump's (1947) series, and 20 per cent in Sherlock and Learmonth's. In these patients there is, presumably, a weak point in the wall of the artery, and the latter has, as a result of pregnancy, to carry a heavier load than normal. Aneurysm formation and rupture follow, or the artery may rupture without an aneurysm having formed (Gillam, 1942; MacLeod and Maurice, 1940).

**Diagnosis.**—It is of the first importance to diagnose an aneurysm before it has ruptured, as the results of treatment at this stage are immeasurably superior to those in cases where rupture has already occurred. In Sherlock and Learmonth's series 19 patients were operated on before rupture and 18 were cured, whereas only 2 survived out of 19 who were operated on after rupture. (In neither of these two cases was an aneurysm actually discovered on the splenic artery, and they should, strictly, be regarded as cases of spontaneous arterial rupture.)

The clinical features, one or more of which may be present before rupture, are:—

1. A complaint of upper abdominal pain, not related to meals.

2. A palpable lump in the left hypochondrium which may be, but is not always, pulsatile.

3. An audible bruit in the left hypochondriac region.

4. A roughly circular, partly calcified opacity, detectable by X rays, in the upper abdomen.

5. A pulsating deformity of the greater curvature of the stomach, as seen at barium meal (Sperling, 1940).

These signs are by no means constant and the diagnosis may be impossible. The patient whose case is reported below was seen by a consulting physician fourteen days before her aneurysm ruptured and the condition was not suspected.

After rupture has occurred, it is even more difficult to make an accurate diagnosis, for the presence of blood in the peritoneal cavity makes any bruit that may be present less easy to hear and reduces the likelihood of a visible shadow being thrown on an X-ray film. In the present case, no bruit was heard although the abdomen was repeatedly auscultated for bowel sounds, and a radiograph of the chest showed no sign of the aneurysm although the area in which it lay was included in the film.

It is very seldom that the condition has been recognized before operation as it is so uncommon, but in a patient who gives a history of upper abdominal pain of rapid onset, and who shows signs of severe shock, it is a diagnosis that should be considered.

A clinical feature worthy of special emphasis is 'two-stage' rupture (Sherlock and Learmonth, 1942). In a number of the recorded cases the patient has appeared to recover from an attack of severe upper abdominal pain, accompanied by shock, only to succumb later to a second attack, which has been proved at operation or autopsy to be due to a ruptured splenic aneurysm. The interval between the two incidents has been anything from one to fifty-five days. Every patient, therefore, in whom this diagnosis is suspected should be operated on without delay, even though there is clinical improvement.

**Treatment.**—The diagnosis having been established at operation by palpation, the aneurysm should be removed. This is a simple matter if it projects forward into the lesser sac, but, in some cases, it has been found that the aneurysm burrows deeply into or behind the pancreas and its removal has been impossible. In this case proximal and distal ligatures should be applied to the splenic artery. Marshall (1922) treated a case successfully in this manner, but Parsons (1936) found that, although by this method the immediate result was good, the patient died 18 months later from a second hæmorrhage at the same site. Proximal ligation alone is useless, as the spleen has a very extensive collateral blood-supply and the aneurysm continues to bleed from its distal origin. In order to apply the proximal ligature, the splenic artery must be approached through the lesser sac. The distal ligature may be applied in the same way, but, if the aneurysm is near the spleen, the best way to apply the distal ligature is to ligate the splenic pedicle in the greater sac. Splenectomy is not necessary as the organ will either be maintained by its collateral blood-supply or become fibrosed.

In the reported cases where splenic arterial hæmorrhage has occurred in the absence of an aneurysm, the site of the arterial rupture has always been very close to the hilum of the spleen, and, the diagnosis having been made by the finding of masses of blood-clot around this point, splenectomy alone has been curative.

The patient has to be kept alive in the face of the very severe arterial hæmorrhage which goes on until the splenic artery can be controlled. To achieve this, blood must be given as rapidly as possible by multiple routes, and an efficient blood bank, which can supply up to five pints of compatible blood without delay, is a prerequisite without which, in the majority of cases, the surgeon will be powerless.

**Prognosis.**—This has been very bad, but, with adequate blood transfusion services being more generally available than in the past, it should improve. Up till now, only 1 case of ruptured splenic arterial aneurysm has been recorded as successfully treated (Marshall, 1922), but there are on record, in addition, 4 cases of spontaneous arterial hæmorrhage from the region of the splenic hilum in which the patient's life has been saved by splenectomy (Brockman, 1930; Gillam, 1942 and 1948; MacLeod and Maurice, 1940).

## CASE REPORT

A married woman of 69 was admitted to hospital complaining of upper abdominal pain, which had started eight hours before. It had not been severe at first, but within three hours had become much worse and had radiated up into the left chest and shoulder. It was "sharp like knives" and steady, not colicky. She had vomited three times since the pain started, bringing up small quantities. Her bowels had been open normally the day before and there was no disturbance of micturition.

With regard to her previous medical history: three months before, she had had glasses prescribed for failing vision which was due to retinal arteriosclerosis; two weeks before, she had been seen by a consulting physician on account of headaches, palpitations, and giddiness—her blood-pressure then was 230/220 and her weight 11 st. 0 lb. 1 oz. Sedatives and a weight-reducing diet were ordered.

ON EXAMINATION.—The patient was pale and shocked. Her temperature was 98·2° F., pulse 104, and respirations 32 per minute. The tongue was furred but moist.

*Cardiovascular System*: The blood-pressure was 110/80, the radial arteries were hard and tortuous, and an apical systolic murmur was heard over the heart. An electrocardiogram showed no evidence of coronary thrombosis.

*Respiratory System*: Clinically, no abnormality was found, while a radiograph of the chest showed a tortuous aorta and some patches of calcification in the pulmonary artery.

*Abdomen*: The patient was very obese, but there was no obvious abdominal distension. There was severe tenderness in the left upper quadrant while palpation elsewhere caused only mild discomfort. The muscles of the epigastrium were on guard, more so on the left than on the right, but the rest of the abdomen was soft. It was thought that shifting dullness was probably present, but it was difficult to be certain on this point. Bowel sounds were less frequent than normal and their character suggested that the intestines were a little distended.

The provisional diagnosis was not definite. In view of the patient's severe arteriosclerosis, it was thought at first that she was suffering from a coronary thrombosis.

However, a degree of shock great enough to cut her systolic blood-pressure to half its usual level was more than would be caused by a coronary thrombosis, and an electrocardiogram, recorded on the spot by Dr. John Wedgwood, finally ruled out the possibility.

The decision to operate was made on the assumption that she was suffering from a volvulus or infarct of the spleen or small intestine.

A blood transfusion was started and, her condition having improved slightly, laparotomy was undertaken two hours after her admission to hospital.

AT OPERATION.—The peritoneal cavity was found to be full of blood, as much as possible of which was removed with a sucker. After a search, a hard, pulsating tumour about 1½ in. in diameter was felt behind the stomach. The lesser sac was then opened through the greater omentum and more blood, some of which was clotted, gushed out furiously. By persistent swabbing and use of the sucker a view of the structures on the posterior wall of the lesser sac was eventually obtained. The mass felt previously was found to be an aneurysm of the splenic artery, which was freely mobile and projected forward into the lesser sac. From its surface blood was spurting—by now very feebly. Artery forceps were applied on either side of the aneurysm and the latter was cut away. The patient's condition was now critical. All bleeding from small vessels had ceased spontaneously and the aortic pulse was imperceptible. The blood transfusion, previously set up into her right arm, was already running at maximum speed. Another was started in a vein of the left arm and a third into the right external jugular vein. While the anæsthetist and assistant were busy with these measures, the spleen was removed and the abdomen closed in layers. Splenectomy was not strictly necessary, but, at the time, it was thought wise to remove an organ the main artery to which had been divided and the collateral blood-supply of which was impeded by severe arteriosclerosis.

A total of four pints of blood was given intravenously in the hour it took to do the operation. She had had one pint beforehand and one more pint was given afterwards, a total of six pints (3·4 litres). When the patient left the theatre for the ward her blood-pressure had been restored to 140/90 mm. Hg.

There were minor complications in the post-operative period. During the first few days there was a certain amount of abdominal distension and difficulty with micturition, and in the second week mild, right, basal pleurisy occurred. She was given penicillin to ward off respiratory infection, and an attack of cystitis, which followed catheterization, was easily controlled with sulphamezathine.

The blood-pressure six days after operation was still only 170/110.

She was transferred to a convalescent home on the twenty-second post-operative day, and, when seen in Outpatients six weeks later, was in as good heath as before the operation. Her blood-pressure had returned to its previous level of 210/130.

THE SPECIMEN.—A large saccular aneurysm (5·6 cm. × 4·0 cm.) of the splenic artery, a tortuous length of which was included. A short length of the splenic vein was adherent to the surface of the aneurysm. The wall of the sac was split at one point and its inner lining bore some calcified, atheromatous plaques. It contained dark-red, laminated blood-clot. (*Figs.* 663, 664.)

The spleen weighed 230 g. and showed no abnormality.

**Comment.**—So far from the correct diagnosis being made before operation, there was, at first, some doubt as to whether the condition was intra-abdominal or intrathoracic. An electrocardiogram, recorded then and there with a portable machine, was of great assistance in excluding a coronary arterial lesion, while the delay thus caused was so slight as to be negligible.

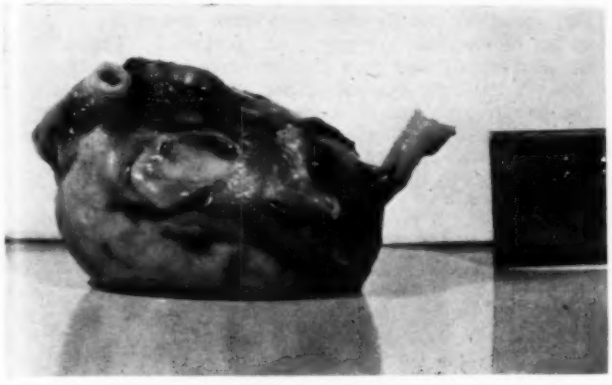

FIG. 663.—Inferior view of the specimen showing a segment of the splenic vein applied to the surface of the sac.

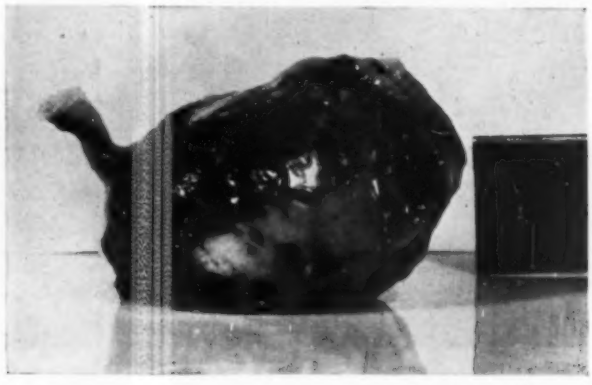

FIG. 664.—Superior view of the specimen. The tear in the wall of the sac can be seen on the left.

## SUMMARY

The literature concerning splenic arterial aneurysm is briefly reviewed.

A case of ruptured splenic aneurysm, which was unusual in that the patient survived, is reported.

I wish to record my thanks to Mr. V. C. Pennell for permission to treat this case and for valuable advice on the preparation of this paper; also to Dr. Jean Randall for administering the anæsthetic.

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# COEXISTENCE OF POLYOSTOTIC FIBROUS DYSPLASIA AND JUVENILE TABES

By A. C. BINGOLD

ORTHOPÆDIC AND TRAUMATIC UNIT, LEWISHAM HOSPITAL, LONDON

In fibrous dysplasia a segment of bone is replaced by fibrous tissue containing immature trabeculæ. One, several, or many bones may be affected. Full accounts of the disorder may be found in the writings of Albright and his colleagues (Albright, Butler, Hampton, and Smith, 1937 ; Albright and Reifenstein 1948) and Lichtenstein and Jaffe (1942).

FIG. 665.—Pathological fracture of the neck of the left femur. Notice the expansion of the left femur, atrophy of the lateral cortex, hypertrophy of the medial cortex, replacement of the normal trabecular pattern by various shades of grey, and a radiolucent area above the left acetabulum. The rest of the pelvis and the right femur are normal. (The opacity above the left hip is an artefact.)

Polyostotic fibrous dysplasia is distinctly rare, juvenile tabes is not common, and the probability of finding both these diseases in one patient must be infinitesimal. The purpose of this article is to report such a patient.

## CASE REPORT

**Polyostotic fibrous dysplasia. Pathological fracture of the neck of left femur. Juvenile tabes. Neuropathic left subtaloid joint.**

CLINICAL DETAILS.—B. T., a 15-year-old girl, sustained a pathological fracture of the neck of her left femur by going over on her left ankle. She was well nourished. Her left hip was tender, and the left leg in lateral rotation. She was covered with freckles, but had no *café au lait* areas. There was no evidence of endocrine disturbance. Her pupils were of average size, did not react to light, but reacted to accommodation. The ankle-jerks were absent. The Wassermann reaction of her blood and cerebrospinal fluid was positive.

On the radiographic appearance (*Figs.* 665, 666) a diagnosis of polyostotic fibrous dysplasia was made. The distribution of the skeletal changes is shown in *Fig.* 667.

Biochemical tests were within normal limits. The patient's blood group was Group A Rh-negative on two occasions.

Her previous medical history was non-contributory.

INVESTIGATION OF THE FAMILY.—The patient was the second child of a family of eight. There had been no miscarriages. Her father, mother, and seven brothers and sisters were examined clinically and showed no evidence of acquired or congenital syphilis or a bone disease. All had negative blood-Wassermann reactions. On screening the bones of the mother and family, no pathological changes were noted. The mother was Group A Rh-positive on two separate occasions.

TREATMENT AND PROGRESS.—The fracture was at first treated by immobilization in a double hip spica. But after six weeks the coxa vara deformity and the width of the fracture gap had increased. Therefore, a tibial cortical graft was driven across the fracture into the head of the femur. Specimens from the neck of the femur and the tibia were obtained for histological examination. A double hip spica was again applied. On its removal after fourteen weeks the fracture was united. Seven months after operation she had a painless left coxa vara with ½ in. of true shortening, but full hip movements (*Fig.* 668). A radiograph taken nineteen months after operation showed that the graft had almost completely disappeared, and that a new trabecular system was developing, by-passing medially the site of the completely healed fracture (*Fig.* 669).

FIG. 666.—Oblique view of the patient's left tibia and fibula. Notice the ground-glass area occupying the middle third of the tibia, the hypertrophied cortex above it, and the expansion of a segment of the fibula associated with thinning of the cortices.

Penicillin therapy (16 mega units in two courses lasting nine and eleven days respectively, with an interval of nine weeks) restored the cerebrospinal fluid to normal,

Although the Wassermann reaction of her blood remained positive. Six months after operation she developed a slightly painful neuropathic left subtaloid joint. She could not remember any injury to her ankle. In spite of calliper, malaria and bismuth therapy, disorganization of the joint progressed (*Figs.* 670, 671), necessitating below-knee amputation.

PATHOLOGICAL STUDIES.—During removal of the bone-graft from the right tibia it was noted that the translucent areas in the radiographs were chiefly medullary and that they were the same colour as the surrounding bone. However, probing with a knife readily identified them, because they felt soft, though gritty.

FIG. 667.—Diagrams showing the distribution of the skeletal changes.

The specimens from the tibia and the femur showed identical histological features, namely trabeculæ of immature bone lined with osteoblasts and a few giant cells, lying in moderately cellular fibrous tissue (*Fig.* 672).

## DISCUSSION

The occurrence of syphilis together with polyostotic fibrous dysplasia is here described for the first time. The source of this girl's syphilis is not known. Nor can any definite statement be made regarding the relationship between syphilis and polyostotic fibrous dysplasia. But it is tempting to speculate that the fibrodysplastic foci in the patient's skeleton represent burnt-out syphilitic lesions.

Such a hypothesis is in agreement with the views of Valls, Polak, and Schajowicz (1950). Since the patient is Rh-negative, but the mother is Rh-positive, the disease is unlikely to have been caused by auto-immunization. Braid (1949) reached similar conclusions.

## SUMMARY

A 15-year-old girl suffering from polyostotic fibrous dysplasia and juvenile tabes has been reported. She sustained a pathological fracture of the neck of the left femur. Treatment was by a bone-graft across the fracture and immobilization in a double plaster spica. Union occurred in fourteen weeks. The fracture was still firmly united nineteen months after operation, and it was protected by a new trabecular system, extending from the

FIG. 668.—Patient's left hip seven months after operation. The graft is well outlined. The fracture is united.

FIG. 669.—Patient's left hip nineteen months after operation. Only the ghost of the graft remains. The fracture remains united. A new trabecular system extends from the upper end of the femoral cortex into the head and neck of the femur. Notice the bismuth injection above the hip.

upper end of the medial femoral cortex into the femoral head and neck, but the graft had become largely absorbed. In spite of vigorous antisyphilitic therapy the patient developed a neuropathic lef

FIG. 670.—The patient's left hindfoot showing a pathological fracture of the left calcaneus six months after the hip operation.

FIG. 671.—Complete disorganization of the left subtaloid joint ten months after the hip operation.

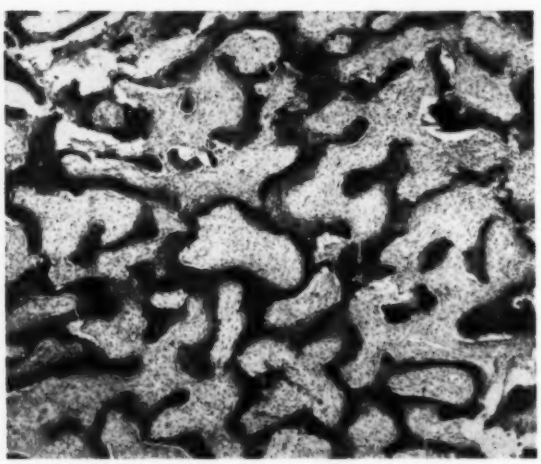

FIG. 672.—Biopsy from the patient's left hip There are trabeculæ of immature bone lying in moderately vascular connective-tissue arranged in whorls. The trabeculæ tend to have osteoid seams and are lined with osteoblasts. (× 27.)

subtaloid joint, which was treated by a below-knee amputation.

It is a pleasure to express my thanks to my late chief, Mr. R. Broomhead, for permission to publish this case and to perform the hip operation; to Dr. D. H. Collins for help with the pathology; to Dr. E. N. Allott for advising me regarding the Rh factor; and to Mr. H. Jackson Burrows for reading my manuscript.

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# MASSIVE RETROPERITONEAL TERATOMA

## REPORT OF A CASE

BY RAPHAEL MARCUS AND A. C. BREWER

RETROPERITONEAL teratomata are rarely encountered in adults. They are usually found in infants. The natural history of these tumours is one of slow growth. Degenerative changes, cyst formation, calcification, and infection may occur in them, although they may be dormant for thirty years. Death can occur from obstruction or malignancy.

### CASE REPORT

E. W., aged 51, was first seen on July 3, 1947, when she complained of a soft swelling in the upper part of the right thigh. The swelling had been present for an indefinite number of years, but during the last two years had enlarged and recently become painful. The appetite was poor and she had lost weight. Physical examination revealed a cachectic patient. A fluctuant non-translucent swelling was situated in Scarpa's triangle and on the medial surface of the right thigh (*Fig.* 673). It could not be reduced, but showed an impulse on coughing. The right leg was grossly œdematous. A large fixed tumour was felt in the right side of the abdomen. It extended from the right costal margin into the pelvis and caused a bulge in the right flank. Fluctuation was elicited between the abdominal tumour and the swelling in the right thigh.

INVESTIGATIONS.—

*X-ray Examination.*—A large soft-tissue shadow was seen in the right side of the abdomen and in the upper part of the right thigh. No abnormality was seen in the lungs. No bony disease in the spine and pelvis.

*Intravenous Pyelography* (*Fig.* 674).—The left kidney showed normal pyelographic appearances. The right kidney and ureter were displaced and rotated to the left. Retrograde pyelography (*Fig.* 675) confirmed the presence of a normal right kidney on the left side of the abdomen.

*Urine*: A few R.B.C.s and pus cells. Culture sterile. W.B.C. 7600 per c.mm.

PROGRESS.—

July 19: 200 c.c. of jelly-like fluid aspirated from swelling in thigh. Sections made from the aspirated

FIG. 673.—Showing the swelling in the grossly œdematous right leg.

material consisted of laminated eosinophilic material which looked like fibrin. Occasionally the arrangement was looser and in small foci, necrotic remains of cellular elements were present, but there was not sufficient structure left to make diagnosis possible.

Aug. 2: 4 pints of jelly-like material aspirated from thigh.

Aug. 13: Aspiration repeated.

Aug. 16: Laparotomy. A large retroperitoneal cystic tumour was seen. It filled most of the peritoneal cavity and displaced the stomach and intestine upwards and to the left. The right kidney was also displaced to the left. The tumour was explored extraperitoneally through a split-muscle incision. Sixty ounces of gelatinous material was scooped out, and the wound then closed in layers.

Sept. 15: Died.

AT AUTOPSY.—A large cystic tumour occupied the whole of the right side of the abdomen, extending from the diaphragm to below the inguinal ligament. The tumour had pushed the cæcum and ascending colon medially and partially overhung both. The right kidney was displaced upwards and to the left. The outer surface of the tumour was smooth, white, and glistening. Its inner surface was ragged and the contents consisted of a large mass of thick yellow-white, gelatinous material, blood-stained in places and obviously infected. Below,

FIG. 674.—Right kidney displaced to the left side of the twelfth dorsal vertebra. The outline of the left ureter is seen in front of the left transverse processes of the lumbar vertebræ.

FIG. 675.—Ureteric catheter in the right ureter, showing the degree of displacement over to the left.

the tumour had herniated through the femoral canal and formed a large swelling in the upper part of the thigh. The uterus, Fallopian tubes, ovaries, kidneys, and other organs were normal.

Section showed a variety of appearances. There was an old cyst containing numerous cholesterol crystals and typical xanthoma cells within its walls. In addition there was a mucin-secreting adenocarcinoma, and these cells were secreting mucin in the interstitial tissue. On one side of the mass there was a fibrous-tissue wall, and on the other side an ulcerated septic area. The condition was suggestive of having its origin in a pseudomucinous cystadenoma of ovarian tissue in a teratoma.

## DISCUSSION

Hansmann and Budd (1931) studied 17 cases of retroperitoneal teratodermoids and believed there is a general explanation for the genesis of these tumours—namely, that they arise from the remnants of the embryonal urogenital apparatus. Frank (1894) attributed the histogenesis of his case to an accessory ovary. It is possible this, too, was derived from the remnants of the embryonal urogenital apparatus.

Retroperitoneal teratomata, because of their size and intimate relations to important structures, may be inoperable. A few cases have been operated on successfully.

Arnheim (1943) reported the fourth successful case in infancy and childhood. Gale and Willis (1944) succeeded in removing a retroperitoneal digi containing teratoma in a girl aged 13. The tumour was approached through an opening in the gastro colic omentum. Smith and Cochrane (1946) en countered a cystic organoid teratoma in the pararenal tissues. Exposure was difficult until nephrectomy was performed. O'Leary and Halpert (1947) operated successfully on a 15-months-old girl with a large retroperitoneal teratoma.

## SUMMARY

A case of a massive malignant retroperitoneal teratoma which presented as a swelling in the leg is reported.

Grateful thanks are due to Mr. Wilfred Lee, of the Central Photographic Department, The University of Liverpool, for the photographs.

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# *REVIEWS AND NOTICES OF BOOKS*

**Surgical Technique.** By STEPHEN POWER, M.S., F.R.C.S., Senior Surgeon to the Dreadnought Hospital, Greenwich; Surgeon to the Royal London Homœopathic Hospital; Surgeon to Eltham Hospital. $4\frac{7}{8} \times 7\frac{1}{4}$ in. Pp. 380 + x, with 198 illustrations. 1951. London: William Heinemann (Medical Books) Ltd. 30s.

THERE are few books devoted to surgical technique and the larger works on surgery rarely include anything on this important subject. It is therefore quite refreshing to read Mr. Stephen Power's book, which contains many practical and useful ideas on surgical technique. To-day, with the fragmentation of surgery into many branches, there is a tendency for surgeons to forget the real background of general principles. This small volume contains information and advice on all aspects of the technique of surgery, including choice of instruments, position of patients, anæsthesia, blood transfusion, and the work of an assistant surgeon.

This book fills a very definite gap in our surgical literature.

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**Wounds of the Extremities in Military Surgery.** By OSCAR P. HAMPTON, jun., M.D., F.A.C.S., Instructor in Clinical Orthopædic Surgery, Washington University School of Medicine; etc. $6\frac{3}{4} \times 9\frac{3}{4}$ in. Pp. 434, with 131 illustrations. 1951. London: Henry Kimpton. 70s.

THIS volume contains the experiences of the author which he gained in World War II while serving with the American forces in Africa, Italy, and France.

Wounds of the extremities made up 60 per cent of the battle casualties and therefore form a large volume of material. The experience in Korea seems to give the same percentage of wounds of the extremities as in World War II.

Although there are many books on war surgery, this is the first book to be devoted to wounds of the extremities, and it is written in an interesting way, with plenty of good illustrations and actual case notes.

The chapter devoted to wounds of the hands should prove of real value to the industrial surgeon who is called upon to treat many and varied forms of hand injury.

This book should be read by all who are interested in traumatic surgery.

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**Surgical Treatment of the Motor-Skeletal System.** Supervising Editor, FREDERICK W. BANCROFT, A.B., M.D., F.A.C.S., Professor of Clinical Surgery, New York Medical College; etc.; and HENRY C. MARBLE, A.B., M.D., F.A.C.S., Consultant, formerly Chief of Fracture Service, Massachusetts General Hospital; etc. Second edition. $6\frac{7}{8} \times 10$ in. In 2 volumes. Pp. 1303, with 1049 illustrations and 3 colour plates. 1951. Philadelphia and London: J. B. Lippincott Co. £9 9s.

THE second edition of this large two-volume production shows careful revision and the inclusion of new illustrations. There are 46 contributors and the whole field of skeletal surgery is very fully covered, and all procedures, operative as well as non-operative, are included in the text. The illustrations in these volumes are numerous and on the whole excellent, but some of the X-ray photographs could be better. One of the best chapters is that devoted to the physiology of bone repair, in which many beautiful photomicrographs are included.

The editors have wisely divided the material into two parts according to the origin of the lesion, with those

due to injury in one volume and those due to other causes in the second volume. Throughout both volumes the emphasis is primarily on surgical treatment. The pattern of presentation includes not only the operation itself, but also indications for it; there is a full discussion of pre-and post-operative care and the possible sequelæ and prognosis. This pattern makes the volumes of exceptional value as a work of reference.

There is a very complete bibliographical index and an excellent subject index, which increase the usefulness of the production.

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**The Apologie and Treatise of Ambroise Paré.** Containing the Voyages made into Divers Places with many of his writings upon Surgery. Edited and with an Introduction by GEOFFREY KEYNES, M.D., F.R.C.S., F.R.C.O.G. 5½ × 8½ in. Pp. 227 + xxxiv. Illustrated. 1951. London: Falcon Educational Books. 15s.

ALTHOUGH there are several books devoted to Ambroise Paré and his times yet Geoffrey Keynes has edited an excellent volume and written an interesting biographical introduction. Paré dominated European surgery in the sixteenth century and still is considered one of the greatest surgeons of all time.

It is quite conceivable that the *Apologie* would never have been written were it not for the fact that certain attacks were made upon his surgical innovations by other surgeons in France. The use of ligatures in amputations seems to have caused a very bitter controversy.

Paré had a unique experience in war surgery, but he was an astute clinical observer and little passed his keen eye. Hence it is that he has written on many and varied aspects of surgery. His general surgical writings included in this volume are chapters on aneurysm, hernia, gunshot wounds, fractures, dislocations, some surgical operations, and a treatise on "How to make reports", that is examinations to determine the cause of death.

The book contains four engravings of Paré at the ages of 45, 65, 68, and 72 respectively. After having read this book one is astonished at the clinical acumen of men of the Paré calibre, who worked with none of the modern aids to diagnosis such as pathological investigations and X rays.

Mr. Keynes has set a high standard in the *Classics of Science Series* and one looks forward to reading the next volumes which are to be devoted to Sir Isaac Newton's *Opticks* and William Harvey's *Circulation of the Blood*.

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**Plastic Surgery of the Nose.** Including Reconstruction of War Injuries and of Deformities from Neoplastic, Traumatic, Radiation, Congenital, and Other Causes. By JAMES BARRETT BROWN, M.D., Professor of Clinical Surgery, Washington University School of Medicine, St. Louis, Mo.; Chief Consultant in Plastic Surgery, United States Veterans Administration; and FRANK MCDOWELL, M.D., Assistant Professor of Clinical Surgery, Washington University School of Medicine, St. Louis, Mo. 6¾ × 10 in. Pp. 427, with 379 illustrations, 48 in colour. 1951. London: Henry Kimpton. 105s.

IT is by far the best of a very large number of books that have been produced on this subject. It is comprehensive and is written in a forceful style, reflecting the very considerable care and attention given to the presentation.

Much thought has been given to the selection of photographs and the numerous diagrams are well executed and abundantly clear. There is some repetition in the sections devoted to nasal reduction, but this is wholly advisable in that it stresses the important aspects of diagnosis, treatment, and the reasons for failure. Chapters have been devoted to special problems such as trauma, the repair of the nasal deformity associated with hare lip, radiation lesions of the nose, tumours of the nose, and some of the rarer nasal deformities.

I must compliment the authors that this book is devoid of the many countless procedures that get copied from text-book to text-book. It is a book that will certainly find a place in the student's and the consulting plastic surgeon's libraries. It is regretted that the selling price in Great Britain is as high as five guineas, but it is an excellent book and I believe will receive wide acclamation.

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**The Radium Commission.** A Short History of its Origin and Work, 1929–1948. Compiled by F. G. SPEAR, M.D., and K. GRIFFITHS, M.B.E. 5⅜ × 8¾ in. Pp. 157, with 16 plates. London: His Majesty's Stationery Office. 7s. 6d.

THIS useful little book is dedicated to the memory of the Earl of Donoughmore and George F. Stebbing, both of whom worked for many years on the Radium Commission. Lord Donoughmore was Chairman of the Commission from 1933 to 1948, while Stebbing was Secretary from 1935 until his untimely death in 1947.

This book gives a very clear and lucid account of the activities of the Commission throughout its existence. The various committees and centres and the relations of the Commission with other bodies are all set out in detail, together with the numerous publications of the Commission. A most handy book of reference.

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**Fractures and Joint Injuries.** By SIR REGINALD WATSON-JONES, B.Sc., M.Ch., Orth. F.R.C.S., F.R.A.C.S. (Hon.), F.A.C.S. (Hon.), Orthopædic Surgeon to His late Majesty King George VI; Director of Orthopædic and Accident Service, The London Hospital; etc. Fourth edition. 6¾ × 9¾ in. In two volumes. Vol. I. 1 p. 467 + xii, with 709 illustrations, many in colour. 1952. Edinburgh: E. & S. Livingstone. £6 per set.

IT is nearly ten years since the third edition of this work appeared and in that time much progress has been made in orthopædic and traumatic surgery. Sir Reginald Watson-Jones has upheld the great tradition of the former editions for he has given us a completely up-to-date and fascinating book on the treatment of traumatic injuries. Volume I of the new fourth edition is a great achievement; it is written with that clarity of diction which is so often missing in surgical books of to-day. The illustrations, which average two per page, are excellent and well chosen, and some are in colour.

The whole set-up and format of the book are beyond praise and it is a great credit to British surgery.

There is a comprehensive index to authors and a subject index.

We look forward with interest to reading Volume II, which we understand will be published about the middle of this year.

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**Tumors of the Skin.** Benign and Malignant. By JOSEPH JORDAN ELLER, B.S., M.D., Director of the Department of Dermatology, New York City Hospital; etc.; and WILLIAM DOUGLAS ELLER, M.D., Assistant in Dermatology and Syphilology, University Hospital, New York–Bellevue Medical Center; etc. Second edition. 6¼ × 9¼ in. Pp. 697, with 550 illustrations and 2 coloured plates. 1951. London: Henry Kimpton. 105s.

THIS well-known work on tumours of the skin has been thoroughly revised and enlarged. Many new illustrations have been added, so many in fact that there is practically a picture per page.

The technique of radiation therapy in the treatment of skin tumours is fully described and all the new methods of application are given. Radio-active isotopes and thorium X are discussed in detail.

There is a useful and comprehensive bibliography.

The book still maintains its position as the best volume on tumours of the skin.

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**The 1951 Year Book of General Surgery** (July, 1950–May, 1951). Edited by EVARTS A. GRAHAM, A.B., M.D., Professor of Surgery, Washington University School of Medicine; etc. With a Section on Anæsthesia edited by STUART C. CULLEN, M.D., Professor of Surgery and Chairman of Division of Anæsthesiology, State University of Iowa College of Medicine and Hospitals. 5⅛ × 7⅝ in. Pp. 621 + viii, with 209 illustrations. 1951. Chicago: Year Book Publishers Inc. (London: Interscience Publishers Ltd.) 40s.

THIS useful year book contains a précis of all the important surgical papers that have appeared in America and in this country. Professor Evarts Graham has a happy knack of picking out the outstanding surgical advances of the year.

It is interesting to note that both here and in America there is strong evidence that cigarette smoking is an important factor in the striking increase of bronchogenic carcinoma.

It is nice to find that surgery of the lungs and heart, and the genito-urinary system are considered within the scope of general surgery.

Once more we would like to congratulate Professor Evarts Graham on a very sound and useful book.

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**Modern Practice in Tuberculosis.** Edited by T. HOLMES SELLORS, M.A., D.M., M.Ch., F.R.C.S., Thoracic Surgeon, Middlesex Hospital; etc.; and J. L. LIVINGSTONE, M.D., F.R.C.P., Physician, King's College Hospital and Brompton Hospital, London. In two volumes. 6⅝ × 9⅝ in. Vol. I, Pp. 355 + xxviii, with 73-p. index; Vol. II, pp. 441 + viii, with index as in Vol I. 1952. London: Butterworth & Co. £7 7s.

THIS large and comprehensive two-volume compendium consisting of some thirty-nine sections sets forth the modern views on tuberculosis. During the last decade many changes have taken place in the treatment of tuberculosis and all these are carefully incorporated in this work.

The numerous contributors are all recognized authorities in their various branches of the subject. The field of tuberculosis is vast and varied, and the medical profession as a whole cannot be expected to know the various aspects of this disease as it affects the different organs and systems of the body. This work will prove a valuable reference compendium, covering as it does all the various branches of medicine and surgery in which tuberculosis may occur. It should be valuable not only to workers in the field of tuberculosis but also to general physicians and surgeons.

The two volumes are beautifully produced and lavishly illustrated and are a great credit to British medicine.

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**The Management of Fractures, Dislocations, and Sprains.** By JOHN ALBERT KEY, B.S., M.D., St. Louis, Missouri; and H. EARLE CONWELL, M.D., F.A.C.S., Birmingham, Alabama. Fifth edition. 6¾ × 10 in. Pp. 1232, with 1195 illustrations. 1951. London: Henry Kimpton. 115s.

THIS is a book of contrasts. It bears its stamp of dual authorship throughout its 1,200 pages. We are constantly impressed by the diversity of opinion between the authors themselves and those who have been quoted. The discourse on the treatment of nerve injuries complicating wounds and fractures omits the established concept upon which our treatment is based. The account of healing of fractures is a very readable essay of wise scientific style which shows how much more is still to be discovered on the subject. Equally valuable is the account of fracture principles in Chapter I. The features which make this book disappointing as a work of reference for orthopædic surgeons are its lack of concentration on points where guidance is most sought, and its far too thorough acceptance of unproved doctrine. There is a mass of information on the diagnosis of particular fractures, and an equally impressive account of the detailed application of the selected type of treatment. But the rationale of selection of any given type of treatment is given scant attention. Thus many methods of plastering the spine in hyperextension are described, but there is no discussion on whether this is in fact the treatment of choice in compression fractures.

This edition, like previous ones, has been concerned with methods in traumatology and it is felt that the omission of any detailed discussion on the principles governing the selection of these methods makes a monograph of this scope inadequate.

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**Surgical Practice of the Lahey Clinic.** By Members of the Staff of the Lahey Clinic, Boston. 6½ × 9⅝ in. Pp. 1014 + xiv, with 509 illustrations. 1951. Philadelphia and London: W. B. Saunders Co. 75s.

THIS large volume contains a wealth of surgical material contributed by various members of the staff of the Lahey Clinic. All the articles have appeared in various medical journals in America during the last few years. The first volume of *Surgical Practice of the Lahey Clinic* was published ten years ago and was immediately acclaimed a most useful book for the practical surgeon. This second volume is even more useful because the material under review is greater and the operative procedures at the Lahey Clinic have become standardized and therefore it is easier to evaluate the results, especially with regard to the treatment of malignant conditions. The volume contains articles which embrace the whole range of surgery, covering the many facets of modern specialization. The surgery of the thyroid, stomach, colon, biliary tract, breast, and central nervous system are included in the volume and make interesting reading. The operative details and the surgical technique are particularly useful and stimulating. The whole book gives the reader much to think about, and to ponder upon the various new methods which during the last decade have been adopted in surgical treatment and practice.

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**Post-Graduate Lectures on Orthopedic Diagnosis and Indications.** By ARTHUR STEINDLER, M.D., F.A.C.S., Professor of Orthopedic Surgery, State University of Iowa, Iowa City, Iowa. Volume II. Section A, Paralytic Disabilities; Section B, Static Disabilities. 6½ × 10 in. Pp. 198 + xiv, with 140 illustrations. 1951. Springfield, Ill.: C. C. Thomas. (Oxford: Blackwell Scientific Publications.) 45s.

PROFESSOR Steindler's teaching now reaches a wider public in the series of Post-Graduate Lectures. His personal approach to the difficult problems under review, his concise statement of his own observations and results, give these volumes a unique clarity which all teachers of orthopædics will welcome. His studies in human kinetics are well known, and in the first section of Volume I he applies them to the analysis of posture and movement, the causation of contractures, and the pathology of

abnormal gaits. In the second section he reviews the theories of the aetiology of congenital deformities, and from a careful study of their pathogenesis and pathology he expounds their treatment on rational lines. Volume II, equally stimulating, is similarly divided into two sections. In the first the author considers the paralytic disabilities, anterior poliomyelitis, and spastic paralysis. He gives a precise outline of specific clinical situations encountered in the former condition and their treatment. In the second section he goes on to discuss the static disabilities of low back pain, paralytic scoliosis, internal derangements of the knee, and deformities of the ankle and foot. Once again his outstanding clarity of thought in analysing the pathological mechanics of these conditions is apparent. His method of approach by the technique of question and answer when considering his own views and those of others, make these volumes an essential addition to the library of all orthopædic surgeons.

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**Essentials of Neurosurgery.** By LESLIE C. OLIVER, F.R.C.S. Eng., Neurosurgeon, West End Hospital for Nervous Diseases, London; etc. 5½ × 8½ in. Pp. 198 + viii, with 50 illustrations. 1952. London: H. K. Lewis & Co. Ltd. 25s.

THIS is a small book devoted to the surgery of the central nervous system. The author states that it is intended as a guide to neurosurgeons in training, but the book does not give enough details to be of real value to the would-be neurosurgeon. It should, however prove of use to postgraduate students who are preparing for higher surgical degrees. The radiographs could have been of higher quality; they lack definition. Too much prominence is given to the surgical treatment of Parkinsonism.

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**The Organization of Bones.** By P. LACROIX, Professor in the Faculty of Medicine, University of Lorain. Translated from the amended French edition by STEWART GILDER, B.Sc., M.B. 5⅜ × 8⅜ in. Pp. 235 + viii, with 87 illustrations. 1951. London: J. & A. Churchill Ltd. 25s.

THE researches of the author in the fields of physiology and micro-anatomy of the skeleton are well known. Herein is a summary of his publications and views of the last ten years, backed by careful experimental observations, in a most readable monograph. Modern views on osteogenesis are expounded against a background of contemporary embryology. It may well be that the day is not far distant when the discovery is made of the existence of an organizing substance in bone. The biological aspects of this hypothesis constitute the primary theme of this work, which will be read with interest by all who, in both clinical and experimental fields, seek to further our knowledge of the basic physiology of bone.

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**Os et Tuberculose.** By ROBERT KAUFMANN. With a Preface by RENÉ LERICHE. 6⅞ × 8⅞ in. Pp. 152. 1950. Paris: L'Expansion scientifique française.

THIS monograph presents a new concept of the origin of tuberculous disease of bone. The author maintains that the infection is never primarily in bone by hæmatogenous spread, but is always secondary to infection of the soft parts, i.e., in adjacent lymphatic tissues. Based on this pathology he performs the operation of "adenectomie" in the early stages of cases of osseous tuberculosis. This involves removal of the adjacent lymphatic tissue; in later stages when an abscess has formed, the operation consists of drainage and curettage of the infected soft parts. The resulting cavity is packed with iodoform gauze and allowed to heal under streptomycin therapy. Detailed case histories of patients with tuberculous lesions in the ribs, sternum, spine, hip, knee, and foot are given. As Professor René Leriche says in his preface, the underlying hypothesis seems reasonable, but further observations are needed before it can gain wide acceptance.

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**Injuries of the Knee Joint.** By I. S. SMILLIE, O.B.E., Ch.M., F.R.C.S. (Edin.), F.R.F.P.S., Lecturer in Orthopædics in the University of St. Andrews; Surgeon-in-Charge, Eastern Region (Scotland) Orthopædic Service; etc. Second edition. 6¾ × 9½ in. Pp. 391 + x, with 451 illustrations. 1950. Edinburgh: E. & S. Livingstone Ltd. 50s.

IN the review of the first edition of this monograph it was described as a large book; it is now even larger—by one-third—and it must be asked whether the growth has been healthy. On the whole it has, for the author has drawn on the results of his increasing experience and on the recent work of other surgeons. But the limit has been reached, and we hope that the well-deserved success of what may now be regarded as the accepted British monograph of injuries of the knee will not tempt Mr. Smillie to produce an encyclopædia. The general arrangement is completely unchanged and the additions consist almost entirely of apposite interpolations. Statistical data, deficient in the first edition, are now a welcome feature, especially in the sections on injuries of the menisci and on repair of damaged cruciate ligaments. In his preface the author confesses that had he attempted to make his analyses complete the second edition would still be unfinished. Yet he must not weary in well-doing, for some of the information about end-results is too brief to be informative or even convincing. In describing transplantation of the tibial tubercle for recurrent dislocation of the patella he tells us "that the results in 34 selected cases in which it has been employed in this series have been entirely satisfactory". Were none of his patients suffering discomfort as a result of degenerative changes in the patello-femoral joint surfaces? This monograph is developing so well that it should be truly authoritative and good statistics will help to make it so. When the next edition appears it need be no larger, for a number of the illustrations could be dispensed with (for example 276, 314, 315, 319, 320, 414, and 421) and some of the conditions of doubtful traumatic origin—such as chondromalacia of the patella and cysts in the popliteal region—could without loss be omitted.

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**The Diagnosis and Treatment of Intrathoracic New Growths.** By MAURICE DAVIDSON, M.A., D.M., B.Ch., Oxon. F.R.C.P. Lond., Consulting Physician to the Brompton Hospital for Consumption and Diseases of the Chest; etc. With a Chapter on Radiotherapy by DAVID W. SMITHERS, M.D., M.R.C.P., D.M.R., and a Chapter on Operative Treatment by OSWALD S. TUBBS, M.A., M.B., B.Chir., F.R.C.S. 6⅞ × 9½ in. Pp. 260 + viii, with 170 illustrations. 1951. London: Oxford University Press. 42s.

THIS book deals with its subject well and simply. It is comprehensive and authoritative but not unduly specialized. It is clearly meant to inform the non-specialist seeking information rather than to be a complete specialist presentation. The chapter by Professor Smithers on deep X-ray therapy is especially interesting and helpful.

It should certainly be read by all those who work with intrathoracic new growths, and some parts of it will prove useful for reference. Our only criticism is that the price seems excessive for a treatise of such relatively limited nature even though the subject is such an important one.

# *BOOK NOTICES*

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]*

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**Scientific Session on the Physiological Teachings of Academician I. P. Pavlov.** 5⅛ × 7⅝ in. Pp. 174. 1952. Moscow: Foreign Languages Publishing House. (London: Collet's Holdings Ltd.) 2s. 6d.

**Warwick and Tunstall's First Aid to the Injured and Sick.** Nineteenth edition. Edited by A. P. GORHAM, M.B., Ch.B., M.R.C.S., L.R.C.P., D.A., Officer of the Order of St. John of Jerusalem; Police Surgeon, City and County of Bristol; etc. 4⅛ × 6½ in. Pp. 278, with 288 illustrations, many in colour. 1952. Bristol: John Wright & Sons Ltd. 6s. 6d.

**Penicillin Decade, 1941–1951.** Sensitizations and Toxicities. By LAWRENCE WELD SMITH, M.D., Medical Director, Commercial Solvents Corporation; and ANN DOLAN WALKER, R.N., formerly Editor, *Trained Nurse and Hospital Review*. 5½ × 8⅜ in. Pp. 122 + viii. 1951. Washington, D.C.: Arundel Press Inc.

**Observations on the General Effects of Injury in Man.** With Special Reference to Wound Shock. Being No. 277 *Medical Research Council Special Report Series*. By R. T. GRANT and E. B. REEVE. 6 × 9⅜ in. Pp. 313 + xiv. 1951. London: His Majesty's Stationery Office. 8s. 6d.

**Cleft Lip and Palate.** By W. G. HOLDSWORTH, M.B., F.R.C.S., Surgeon, Rooksdown House, Basingstoke; etc. With a Foreword by Sir Harold Gillies, C.B.E., F.R.C.S. 7⅜ × 9⅞ in. Pp. 126 + xii, with 87 illustrations and 7 coloured plates. 1951. London: William Heinemann (Medical Books) Ltd. 35s.

**Antibiotic Therapy.** By HENRY WELCH, Ph.D., and CHARLES N. LEWIS, M.D. Division of Antibiotics, Food and Drug Administration, Federal Security Agency of the United States Government. With a Foreword by CHESTER S. KEEFER, M.D., Wade Professor of Medicine, Boston University School of Medicine; etc. 5⅝ × 8⅜ in. Pp. 562 + xiv. Illustrated. 1951. Washington, D.C.: The Arundel Press Inc. $10.00

**Bulletin of the Hospital for Joint Diseases,** October, 1951. Being Volume 12, No. 2. A volume in Tribute to Dr. Henry L. Jaffe.

**Mind: A Social Phenomenon.** Illustrated by the Growth of Medical Knowledge. By F. S. A. DORAN, M.A., M.D. (Cantab.), F.R.C.S., Clinical Demonstrator in Anatomy, University of Manchester. 5 × 7¾ in. Pp. 182 + viii. 1952. London: C. A. Watts & Co. Ltd. 10s. 6d.

**A Synopsis of Neurology.** By W. F. TISSINGTON TATLOW, M.D., M.R.C.P., J. AMOR ARDIS, M.B., Ch.B., D.P.M., and J. A. R. BICKFORD, M.R.C.S., L.R.C.P., D.P.M. 4⅞ × 7¼ in. Pp. 513 + xii, with 84 illustrations. 1952. Bristol: John Wright & Sons Ltd. 30s.

**Emergency Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), F.A.C.S., F.I.C.S., F.R.S.E., Emeritus Surgeon, Royal Northern Hospital, London; etc. Assisted by NORMAN M. MATHESON, M.B., Ch.B., M.R.C.P. (Lond.), F.R.C.S. (Eng.), F.A.C.S., Surgeon, Ashford Hospital, Middlesex. Sixth edition. In five parts. 6½ × 10 in. Part IV. Pp. 193 + iv, with 311 illustrations, many in colour. Bristol: John Wright & Sons Ltd. 21s.

**Callander's Surgical Anatomy.** By BARRY J. ANSON, M.A., Ph.D. (Med. Sc.), Professor of Anatomy, Northwestern University Medical School; and WALTER G. MADDOCK, M.S., M.D., F.A.C.S., Elcock Professor of Surgery, Northwestern University of Medical School. Third edition. 7 × 10 in. Pp. 1074 + xii, with 929 illustrations. 1952. Philadelphia and London: W. B. Saunders Co. 70s.

**Transactions of the Twenty-fifth Meeting of the Northern Surgical Association.** Held in Copenhagen, June 27–29, 1951. 6¼ × 9¾ in. Pp. 460 + xvi. 1951. Copenhagen: Ejnar Munksgaard. 26s.

**Lung Abscess.** By R. C. BROCK, M.S., F.R.C.S., F.A.C.S., Thoracic Surgeon to Guy's Hospital; Surgeon to the Brompton Hospital. 7⅜ × 9⅝ in. Pp. 197 + vi, with 60 illustrations. 1952. Oxford: Blackwell Scientific Publications. 35s.

**The Life and Work of Astley Cooper.** By R. C. BROCK, M.S., F.R.C.S., F.A.C.S., Surgeon to Guy's Hospital; formerly Astley Cooper Student, Guy's Hospital. 6¼ × 8¾ in. Pp. 176 + viii, with Frontispiece and 14 plates. 1952. Edinburgh: E. & S. Livingstone Ltd. 20s.

**Textbook of Surgical Treatment.** Including Operative Surgery. Edited by C. F. W. ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S.E., F.R.F.P.S. (Glas.), Regius Professor of Surgery, University of Glasgow. Compiled by Twenty-two Contributors. Fourth edition. 6 × 9⅝ in. Pp. 744 + xii, with 381 illustrations. 1952. Edinburgh: E. & S. Livingstone Ltd. 45s.

**Portrait of a Surgeon.** A Biography of John Hunter. By ERNEST A. GRAY. 5½ × 8½ in. Pp. 219 + x. Illustrated. 1952. London: Robert Hall Ltd. 16s.